

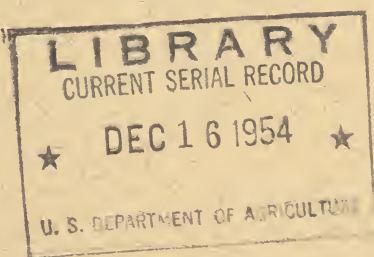
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An Economic Study Of Rough Rice Storage In the Southern States

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This report presents the results of a study of rough rice storage in the Southern States conducted in cooperation with the Louisiana Agricultural Experiment Station. S. A. Robert, Jr., Agricultural Marketing Service, was project coordinator for the U. S. Department of Agriculture.

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SUMMARY

1. The objectives of this study were (a) to appraise, by type and ownership, the existing storage facilities for rough rice in the Southern Rice Area in relation to current and future storage needs, (b) to determine the costs of storage of rough rice under the various types of units used and methods employed, and (c) to evaluate the problems involved, and possible solutions to these problems, in storing rough rice for commercial use and for seed.
2. A stratified random sample of 63 commercial rough rice storage units was selected, including 23 units in Louisiana, 21 in Texas, 17 in Arkansas, and 2 in Mississippi. A detailed business analysis was made of each of these units for the 1951-52 rough-rice storage season.
3. An additional sample of 25 on-farm rough-rice storage units was surveyed, including 17 units in Arkansas, 6 in Texas, and 2 in Louisiana. Supplementary data were obtained from State and Federal agencies and leaders of the rice trade in the area.
4. The overall picture of available storage capacity for rough rice in relation to production in 1951 in the Southern Rice Area indicated that sufficient storage capacity existed to care for practically all the volume produced. (Increased production since 1951 may have changed this balance but some increases in storage capacity have accompanied increases in production.) Not all this capacity is available for public use, indicating that producers might not have sufficient capacity available in years of slow movement.
5. By States and types of storage, however, the analysis indicates that some difficulties could be experienced in any year in which a slow market for rough rice developed early in the harvest season. Louisiana had sufficient total storage capacity, but two-thirds of this volume was of the more expensive old-type flat warehouse capacity. Texas had only about two-thirds the needed storage capacity and half of this volume was in flat warehouse units. Arkansas had sufficient bulk storage capacity to care for the volume produced in 1951, but no surplus capacity was available for a larger volume of production.
6. About 80 percent of the commercial rough rice storage units studied were multiple-purpose enterprises operating rice driers, merchandise sales enterprises, and other services in addition to storage of rough rice. In Louisiana, most of the units were combined bulk and flat-warehouse businesses with driers, or flat warehouse storage firms without driers. In Texas, about half of the units studied were the more recent bulk storage businesses with driers, while in Arkansas practically all firms were of this type.
7. About half of the rough rice storage units studied were operated as incorporated businesses or partnerships, a fourth were operated by private individuals, and a fourth were farmer cooperatives. The different ownership groups did not vary significantly as to type of business.

8. The units studied had an average storage capacity of almost 100,000 hundredweight of rough rice and utilized about 80 percent of this capacity in storing rough rice during the 1951-52 season. The businesses operating both bulk and flat warehouse storage in addition to driers had a larger capacity and volume stored than the other types of businesses. By States, units in Louisiana had the lowest average volume, those in Texas were next, and those in Arkansas had the largest volume. The trend appears to be toward construction of larger-volume units of each type than was true 10 to 20 years ago.
9. Variations in market demand appear to be important in determining the relative utilization of storage capacity. In a season of good early-season demand, much of the rice moves directly from driers to rice mills. In seasons of slower demand, most of the product is stored. The 1951-52 storage season was characterized by a fairly rapid movement of rough rice to rice mills.
10. For all commercial units studied, the original cost per unit averaged \$191,200; the depreciated value in 1952 was \$148,811; the market value in 1952 was \$200,261; and the estimated replacement cost was \$230,201 per unit. Units operated in connection with driers had the highest capital values while those without driers had values only one-fourth to one-third as large. In general, the market value in 1952 was 30 percent greater than the depreciated value and the replacement cost was about 50 percent larger than the depreciated value in 1952.
11. For units operating driers along with storage facilities, about one-third of the total capital invested was considered investment in driers and other equipment and two-thirds was in the form of storage facilities. Average capital values for storage facilities varied from \$1.03 per hundredweight of storage capacity as the depreciated value in 1952 to \$1.67 per hundredweight of capacity as the replacement cost in 1952. There were no significant differences as to capital costs for the various types of building materials used in constructing storage facilities for rough rice.
12. Total expenses during the 1951-52 season averaged about \$67,000 per business; about one-fourth of this amount was for direct labor and management, one-half for operating costs, and one-fourth for overhead expenses. Because of a larger volume, units operating both bulk and flat warehouse storage in addition to drying and other operations had total costs about twice the level of the other types of businesses.
13. Total gross income amounted to \$79,613 per business. Of this income, about 52 percent was from drying charges, 27 percent from merchandise sales, 13 percent from rice storage income, and 8 percent from other sources. Net income after deducting all costs amounted to \$12,513 per unit.
14. The average net income per unit varied directly with the volume of business and the degree of multiple-unit operation. Units having both bulk and flat storage, drying facilities, and supply enterprises, and

offering other needed services to farmers had net incomes more than twice as great as those specializing only in rice storage.

15. The net operating income before interest varied from 9.8 percent of the depreciated value of capital invested to 6.3 percent of the replacement cost of the capital investment. Based on the actual depreciated value of investments in the business, returns were reasonably good. Based on the market value or replacement costs, returns were not high. If the 1951-52 net returns are representative of long-time conditions, net returns will be sufficiently high to justify multiple-purpose rough rice storage units where a sufficient volume is available, but they will not be high enough to justify a large expansion in such businesses.
16. In the event that expanded storage facilities are needed, many businessmen will be reluctant to make extensive investments with an expected return of only 6 percent on the capital investment before paying interest and income taxes. Thus, long-time financing adapted to the needs of the rice industry will be needed for any expansion beyond current levels.
17. An approximation of storage costs and returns separate from the other enterprises conducted by the businesses studied indicated that rough rice storage operations were usually conducted on a cost-covering or service basis in order to obtain the income from the more profitable enterprises such as rice drying. Unit costs averaged about 13 cents per hundredweight of rough rice stored and the net income was 1 cent per hundredweight.
18. In comparison to bulk storage and handling, seed rice had additional costs of about \$0.60 per hundredweight stored. These extra costs were for more careful drying to prevent contamination, labor for sacking, costs of sacks, and expenses for seed cleaning and treatment.
19. In a detailed study of the storage operations of 12 rough rice storage units, each cooperator was visited at monthly intervals and a sample of each lot of rice stored was obtained. These lots were evaluated as to various quality factors. A total of 458 samples were studied in this manner during the 1952-53 storage season.
20. For both long-grain and medium-grain types, the most important change in physical characteristics was a gradual increase in the moisture content during the season. In addition, there were minor changes in the proportionate yield of head rice and total milled rice. In general, head rice and total rice yield increased slightly from the first to the second month of the storage season and then declined slightly during the remaining months of the storage period.
21. There was little difference in the variation in quality factors according to the method of storage. The lots stored in bulk bins varied about the same amount in the same direction during the season

as the lots stored in bags in flat warehouses. For both types of storage, there was a gradual increase in germination during the storage season.

22. Most of the on-farm storage facilities for rough rice were in Arkansas. This was due to the prevailing type of farming which permitted greater utilization of on-farm storage capacity than was possible in other States. In Arkansas, it was possible to use storage capacity for on-farm storage of oats, soybeans, lespedeza seed, and similar crops as well as for rough rice.
23. Farms on which storage facilities for rough rice had been constructed were about twice as large as the usual rice farm of the region. They harvested more than 400 acres of rice per farm, produced 10,000 hundredweight of rice per unit, and sold 22 percent of this volume at harvesttime, stored 62 percent in on-farm storage units and the rest in commercial storage units.
24. The producers surveyed made a gross return of from \$0.50 to \$0.65 per hundredweight of rice stored because of the increase in price during the storage period. This amounted to an increase of 11 percent in the average price during the season. As commercial storage costs per unit were only about half this increase, their margin of gain over commercial storage costs was about 5 to 6 percent of the value of the rough rice if it had been sold at harvesttime.
25. Considering the actual costs of storage in on-farm units, the margin of return for storage was somewhat higher than this level. Unit costs of storage on farms for the 1951-52 season varied from 10 cents per hundredweight for farm units with conventional driers to 11 cents for those with bin driers and 19 cents for farm units without driers.
26. For on-farm storage units without driers, an investment cost in terms of depreciated value of \$10,000 per unit was needed and the replacement cost of these facilities was in excess of \$15,000. For units with driers, total investment costs were from two to four times as great. Such costs can be recovered only over a long period of time and the rice farmer with his relatively low volume of business would find them difficult to carry. In addition, on-farm storage sometimes results in extra costs of marketing. These are major factors which have retarded the establishment of on-farm storage facilities for rough rice.
27. The major reasons given for the establishment of on-farm storage units was the desire to have storage capacity every year in order to be able to hold for higher prices; the feeling that rice could be stored cheaper on the farm than in commercial units; and the need for drying facilities so that the crop could be harvested at the optimum time.
28. The reported disadvantages of on-farm storage of rough rice were the extra costs of handling; the speculative nature of holding rice over a period of time; the danger of losses due to insects, rodents, and physical changes; and the difficulties of marketing small lots of rice.

AN ECONOMIC STUDY OF ROUGH RICE STORAGE IN THE SOUTHERN STATES

By

J. Norman Efferson, Roane Hathorn, and Arthur Gerlow 1/

During and since World War II rice production has increased materially in the Southern Rice Area States, which include Arkansas, Louisiana, Texas, and Mississippi. Compared with the 1935-39 average, the 1952 crop was 39 percent greater in Louisiana; 140 percent in Arkansas; and 148 percent more in Texas. For the Southern States as a whole, the volume of rice produced in 1952 was about double that harvested in 1935-39. This expansion has brought about a need for additional storage facilities for rough rice.

In addition to the increase in production, mechanization of the rice harvest has introduced other storage problems. The old-type binder and thresher harvesting operations were well adapted to sacking and flat warehouse storage. The rice was shocked and air-dried in the field, then moved directly from the field, in sacks, to permanent storage. But the introduction of the combine-drier method developed a need for mechanical drying equipment and bulk storage facilities in order to utilize more efficiently the new method of harvesting. By 1952, about 90 percent of the rice harvested in the Southern States was harvested by the combine-drier method. This rapid change in harvesting methods during the last 10 years has brought about the establishment of many different types of bulk storage units. Even with this trend, much of the rice harvested in recent years of necessity has been stored in old-type flat warehouses. This practice requires sacks for storage and considerable hand labor for sacking and moving the sacks to and from storage. The relative costs of storing rough rice in flat warehouses as compared with the different types of bulk storage facilities have become a primary concern to the southern rice industry.

During the storage of rough rice, deterioration in grade may occur from physiological changes in the product, and losses may result in varying degrees from rodent and insect damage. The extent and economic costs of such deterioration in the different types of storage units used are not known. Thus the relative efficiency of the different methods of storage has become of major interest to the industry in a period when production is expanding and additional storage facilities may be needed.

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The objectives of the study reported here were: (1) To appraise, by type and ownership, the existing storage facilities for rough rice in relation to current and future storage needs, (2) to determine the costs of storage of rough rice under the various types of units used and methods employed, and (3) to evaluate the problems involved and propose possible solutions to these problems in storing rice for commercial use and for seed. Part II of this overall contract study was concerned with an economic appraisal of the deterioration of rough rice in storage under different methods and a measurement of the physical and economic losses due to rodent and insect damage.

Scope and Method of Study

The greater emphasis in this study was placed on the appraisal of commercial rough rice storage units. Although in the Southern Rice Area rough rice is commonly stored in warehouse storage units outside the production area, such as the general-purpose storage facilities at terminal markets including New Orleans, Lake Charles, and Houston, and a considerable quantity is stored by rice millers at their mills, these types of commercial units were not included in this study. This storage is normally after the ownership of the rice has transferred from the producer. Within the rice region, the crop is stored either in on-farm units or commercial units where the producer or cooperative maintains ownership of the rice during storage. Most of the rice produced in the region is stored in the commercial type unit operated as a cooperative, or as an independent private business under the control of an individual, partnerships, or corporations.

A stratified random sample of 63 commercial storage units for rough rice was selected, consisting of 23 in Louisiana, 21 in Texas, 17 in Arkansas, and 2 in Mississippi. A relatively larger sample was taken in Louisiana and in Texas because of the wider variation in types of storage in these States than in Arkansas. The sample was stratified according to location, type of storage unit, and type of ownership before the random selection within these stratifications was made. Each selected unit was contacted for cooperation in the winter and early spring months of the 1951-52 storage season. In a series of two or more visits during the spring, summer, and fall of 1952, detailed information was obtained on costs of establishment and operation, and storage and management practices. Because of the difficulties of separating costs of operating storage units from milling operations where storage units were maintained, such storage units were not included in the sample.

An additional sample of 25 on-farm storage units was selected, including 2 in Louisiana, 6 in Texas, and 17 in Arkansas. The number studied was relatively small in Louisiana and Texas because practically all the rice stored in these two States was stored in commercial off-the-farm units. Each of the on-farm storage units selected was visited during the summer and fall of 1952 and detailed information was obtained on their storage practices, costs, and problems for the 1951-52 storage season.

Supplementary data were obtained from State and local Agricultural Marketing Service grading offices in each area. Prior to the actual collection of data from commercial and on-farm storage units, the schedules used were checked with State and Federal agencies in the region, cooperatives, and leaders of the rice industry in each State.

Rough Rice Storage Needs and Capacity

In 1951, 1,653,000 acres of rice were harvested in the Southern States Rice Area, including Louisiana, Texas, Arkansas, and Mississippi, and a total of 35.1 million 100-pound units of rough rice were produced. Texas produced 13.5 million hundredweight; Arkansas harvested 9.0 million units; Louisiana had 11.9 million, and Mississippi produced slightly more than one-half million hundredweight (table 1).

Table 1.- Acreage and production of rice in the Southern Rice Area, average, 1941-1950; annual, 1951 and 1952

Acreage Harvested						
Year	Louisiana	Texas	Arkansas	Mississippi	Total Southern Area	
	1,000	1,000	1,000	1,000	1,000	1,000
	acres	acres	acres	acres	acres	acres
1941-50 average	588	429	313	---		1,330
1951 - - - - -	612	569	445	27		1,653
1952 - - - - -	588	552	454	48		1,642
Production						
	1,000	1,000	1,000	1,000	1,000	1,000
	hundred-	hundred-	hundred-	hundred-	hundred-	hundred-
	weight	weight	weight	weight	weight	weight
1941-50 average	10,248	8,668	6,871	---		25,787
1951 - - - - -	11,934	13,514	9,011	662		35,121
1952 - - - - -	12,642	13,662	9,420	1,056		36,780

Bureau of Agricultural Economics, 1952 Annual Summary, Crop Production.

If all the rice produced had been stored, a total storage capacity for the region as a whole of approximately 35 million 100-pound units would have been needed. The rice harvest begins in mid-August and continues through early November. As rice mills usually speed up operations with the harvest of the new crop, storage is not needed for that portion of the harvested

rice which moves directly to the mills. However, because market demand for rice is relatively constant throughout the year, most of the rice produced must be stored for one or more months before being milled. In the 1934-43 period, the percentage of the crop sold by farmers each month was as follows: 2/

Month:	Percent	Month continued	Percent
August	3.8	February	8.5
September	10.6	March	6.5
October	20.5	April	4.1
November	16.8	May	4.0
December	10.1	June	3.1
January	10.1	July	1.9

In recent marketing seasons, including the 1951 and 1952 crop years, export demand for rice has been sufficiently strong for a larger proportion of the total crop to move directly to mills for immediate processing. This has reduced the pressure on storage facilities. In any year when demand appears low in relation to available supplies, the tendency will be for a smaller proportion of the total crop to move direct to mills for immediate processing at time of harvest and for a corresponding increase in the proportion of the production which is placed in storage.

A complete inventory of the number and storage capacity of all commercial rough rice storage units in the major States of the Southern Rice Area was made by each of the State offices of the former Production and Marketing Administration at the beginning of the 1951-52 rough rice storage season. The results of this survey, showing the number and type of commercial storage units in each State and the storage capacity in terms of bulk capacity and flat warehouse capacity are presented in table 2.

The total indicated rough rice storage capacity for the three major States was about 31 million hundredweight. If an estimated 1 million hundredweight in on-farm storage units and approximately one-half million for both types of storage in Mississippi is added to this total, the total capacity amounts to 33.5 million units as compared with the harvested production that year of 35.1 million hundredweight. In addition to this estimated total storage capacity of 33.5 million hundredweight, an undetermined but substantial storage capacity existed in the multiple uses which could be made of some facilities where early rice harvested in August was moved to market in time to be replaced with late rice harvested in October and November, and in terminal warehouses. Thus, the overall picture of available storage capacity in relation to actual production in 1951 for the Southern Rice Area indicated that sufficient capacity existed to care for the crop that was produced, and for any future crop equal to the volume

produced in 1951. This reflects total storage capacity and may not indicate the amount available to the producer on a custom basis. Additional capacity may be needed to allow the producer more freedom to sell advantageously.

Table 2.- Commercial rough rice storage capacity in the major rice regions of the Southern Rice Area, 1951

Storage Units								
	:	Louisiana	:	Texas	:	Arkansas	:	Total, 3 States
	:	<u>Number</u>	:	<u>Number</u>	:	<u>Number</u>	:	<u>Number</u>
Bulk storage only	:	33	:	29	:	87	:	149
Flat storage only	:	92	:	21	:	2	:	115
Both bulk and flat	:		:		:		:	
storage - - - - -	:	46	:	33	:	12	:	91
Total - - - - -	:	171	:	83	:	101	:	355
	:		:		:		:	

Capacity								
	:	<u>100 pounds</u>	:	<u>100 pounds</u>	:	<u>100 pounds</u>	:	<u>100 pounds</u>
Bulk storage - - - -	:	3,364,493	:	4,402,225	:	9,117,972	:	16,884,690
Flat storage - - - -	:	9,161,875	:	4,462,812	:	433,800	:	14,058,487
Total - - - - -	:	12,526,368	:	8,865,037	:	9,551,772	:	30,943,177

Based on reports from the various State offices of The Production and Marketing Administration.

By States, the indicated available commercial storage capacity (table 2) varied in its relationship to the volume of rice produced (table 1). Louisiana, with 171 storage units and a commercial storage capacity of 12.5 million hundredweight in 1951, compared with a total production of 11.9 million hundredweight in 1951 and 12.5 in 1952, has sufficient total capacity to care for the State's crop if it is not increased beyond 1951-52 levels. However, three-fourths of this capacity was in the form of the old-type flat warehouse storage units. As practically all the crop is harvested by the combine-drier method, this means that rice stored in these flat warehouses must be sacked at the drier at an additional labor cost which, in 1951, averaged 10 cents per 100 pounds, in sacks bought at a cost of about 20 cents per 100-pound sack, and then transported to the flat warehouse. At the flat warehouse, labor costs for moving sacked rice into and out of storage are usually higher than similar costs for moving bulk rice. Thus, the use of flat warehouse facilities results in higher costs for sacks, sacking, and handling than would be the case if bulk storage facilities were available. This spread in costs is less, however, for seed rice than

for marketable rice moving to mills because seed rice is normally sacked, sooner or later, for ease in handling and distribution during the planting season.

Texas had a total storage capacity of about 8.7 million hundredweight compared with a total production of 13.5 million units in 1951 and 13.6 million in 1952. As very little rice is stored on farms in this State, these data indicated a total storage capacity only about three-fourths of the production level in 1951; slightly more than half of this was in the form of the old-type flat warehouse sack storage.

Arkansas had a total reported storage capacity in commercial units for the 1951 season of about 9.6 million hundredweight, compared with a total production of 9.0 million hundredweight in 1951 and 9.4 million in 1952. Practically all these facilities were of the bulk storage type. This State appeared to be reasonably well supplied with adequate storage facilities for rough rice, in terms of both volume and type, to care for production levels approximating the 1951 and 1952 seasons.

Although the overall picture of storage capacity in relation to production in the 1951-52 period revealed that the Southern Rice Area was reasonably well supplied with rough rice storage capacity, the analysis of the data by States and types of storage available indicates that in any year in which a slow market existed during the early months of the harvest period difficulties could be experienced in some parts of the region 3/. In Louisiana and Texas, much of the available storage capacity was in the old-type flat warehouses which necessitated costs approximating 30 cents per hundred pounds for sacks, sacking and handling sacked rice; but these expenses were not incurred in the usual bulk storage operation. This indicates a need for developing methods of efficiently converting the existing large flat warehouse facilities in these two States to the more modern bulk storage facilities in order to take full advantage of the new methods of harvesting and drying, and to avoid costs of sacking and handling in storage. Throughout Texas and to some extent in the northern section of Arkansas the total local capacity was insufficient to care for storage of the rice produced in these areas in 1951 and 1952, thus pointing out the need for additional facilities in these regions.

It should be noted that when available storage facilities for rough rice are controlled by rice millers and exporters in a slow marketing season, a serious problem could result from sacrifice sales by producers if freely available independent storage was not available to them. Most of the storage capacity for rough rice in the Southern Rice Area is in the form of independent commercial units or farmer cooperative units. In 1949, however, only 58 percent of the total storage capacity in Texas was available for

3/ Increased production since 1951 may have changed the balance between storage capacity and production even though some additional storage facilities have been constructed.

public use and 51 percent in Louisiana 4/. Additional facilities may be needed in these areas if producers are to gain from using storage to sell more advantageously. Most of the storage capacity in Arkansas is cooperatively owned.

Characteristics of Commercial Storage Units

Commercial storage units for rough rice are usually operated in connection with a rice drier. Of the 63 rough rice storage units studied in the Southern Rice Area for the 1951-52 season, 51 were operated in connection with driers. Of these units, about half had both bulk and flat warehouse storage capacity combined with the drying enterprise, while the rest had only bulk storage facilities. The remaining 12 units, operated without a rice drier, consisted of 8 which were solely flat warehouse storage units, 2 which were solely bulk storage units, and 2 which had both flat and bulk facilities (table 3).

Table 3.- Type of business of 63 rough rice storage units in different regions, Southern Rice Area, 1951-52 storage season

Type of business	: Louisiana	: Texas	: Arkansas and: Mississippi	: Total, all units				
	: Num- ber	: Per- cent	: Num- ber	: Per- cent	: Num- ber	: Per- cent	: Num- ber	: Per- cent
Bulk and flat storage	:	:	:	:	:	:	:	:
with drier - - - - -	: 12	: 52	: 11	: 54	: 1	: 5	: 24	: 38
Bulk storage only	:	:	:	:	:	:	:	:
with drier - - - - -	: 1	: 4	: 8	: 38	: 18	: 95	: 27	: 43
Bulk and/or sack storage:	:	:	:	:	:	:	:	:
without drier - - - - -	: 10	: 44	: 2	: 10	: 0	: 0	: 12	: 19
Total - - - - -	: 23	: 100	: 21	: 100	: 19	: 100	: 63	: 100

1/ Includes 17 units in Arkansas and 2 in Mississippi.

The combined storage-drying business represents a logical development reflecting the practices commonly followed in handling rough rice. Under the combine-drier method of harvesting, the usual practice is to combine in bulk, move the harvested rice from the combine to trucks in bulk grain carts, and transport the combined rice to the drier in bulk. At the drier, the rice is dumped into the receiving bin and moved immediately into the

4/ 1949 Production and Marketing Administration capacity studies.

drier for the first step in the drying operation. If a high-quality product is to result, rice harvested with a usual moisture content varying from 20 to 25 percent must be placed in the first stage of the drying process within a relatively few hours after it is combined 5/.

Rough rice is ordinarily dried in column-type continuous flow driers in a series of steps, alternately removing a part of the excess moisture and permitting the rice to condition or temper for a period of time between drying operations 6/. Thus, all such driers must have some bulk bin capacity for use as garner or conditioning bins in the progressive drying process. At the end of the season, when all rice is dried, the bulk garner bins usually are used for storage. As a result, all such driers have some bulk storage capacity. The units with both bulk and flat warehouse capacity are the older flat warehouse units which have been modernized by the addition of a drier and some bulk facilities, or they are specialized bulk-drier operations where some flat warehouse capacity has been added to serve producers of seed rice.

Variations in Type of Business in Different Areas

As indicated in table 3, the type of rice storage business varied greatly in the three major States of the area. In Louisiana, about half of all units studied were bulk and flat storage units with driers and the remaining businesses were storage units operated without driers. Most of the latter were the flat warehouse type.

In Texas, approximately half of all commercial storage businesses studied were the drier units operated in connection with both bulk and flat warehouse storage facilities. More than three-fourths of the rest were more recent driers with bulk storage facilities only. In Arkansas and Mississippi practically all units studied were those with driers and bulk storage facilities only.

These differences may be explained in terms of the length of time the different areas have been in the rice business. In Louisiana, where rice has been a major crop for more than 40 years, the many flat warehouse storage facilities originally were built for use with the now obsolete binder-threshing harvesting methods. As these facilities still exist and represent large investments, this region has been slower to establish bulk storage facilities. Substantial rice areas in Texas were also important producers before the combine-drier harvesting method was adopted and the

5/ LOUISIANA AGRICULTURAL EXPERIMENT STATION. Rice Drying and Storage in Louisiana. La. Bul. 416, 22 p., illus. April 1947.

6/ TEXAS AGRICULTURAL EXPERIMENT STATION, ARKANSAS AGRICULTURAL EXPERIMENT STATION, AND LOUISIANA AGRICULTURAL EXPERIMENT STATION. Recent Research on Drying and Storage of Rough Rice. South. Coop. Ser. Bul. 29, pp. 10-12. January 1953.

flat warehouse storage facilities in those areas are still in use. Much of the expansion in rice production in Arkansas and all of the expansion in production in Mississippi came after the introduction of combines and rice driers. As a result, practically all the storage facilities in these areas are of the more recent type; namely, driers with bulk storage only.

Variations in ownership:

About half of the rough rice storage businesses studied were operated as incorporated businesses or partnerships. These were purely private business establishments operated with the expectation of earning a profit from rice drying, rice storage, and providing of other services to the community. There was no indication that these private enterprise businesses specialized in any one type of rice storage operation (table 4).

Table 4.- Type of business and ownership, 63 rough rice storage units, Southern Rice Area, 1951-52 storage season

Type of business	Company		Individual		Cooperative		Total,	
	or						all units	
	partnership							
	Num-	Per-	Num-	Per-	Num-	Per-	Num-	Per-
	ber	cent	ber	cent	ber	cent	ber	cent
Bulk and flat								
storage with drier	15	44	3	19	6	46	24	38
Bulk storage only								
with drier - - - -	15	44	5	31	7	54	27	43
Bulk and/or sack								
storage without								
drier - - - - -	4	12	8	50	0	0	12	19
Total - - - - -	34	100	16	100	13	100	63	100

Nearly 25 percent of the total businesses studied were operated by private individuals. Half of these units were the bulk or flat storage type without drier facilities. About 20 percent of all units studied were operated as farmer cooperatives. The cooperative units were all operated as both drier and storage businesses and were about equally divided as to bulk storage only and those with both bulk and flat storage.

The most significant variation in ownership within the different States was in Arkansas where a larger proportion was operated as farmer cooperatives than in the other States.

Storage capacity and volume stored:

For the 63 units studied, the total storage capacity per unit was about 96,000 hundredweight. In comparison, they stored only 76,000 hundredweight per storage unit during the 1951-52 storage season. This represents an average utilization of approximately 80 percent (table 5).

The cooperators surveyed reported that available storage capacity was not fully utilized during the 1951-52 storage season because of three major factors: (1) The unusual rice marketing season in late 1951 which caused much of the rice produced to move directly to the mills from the driers; (2) the fact that part of the reported storage capacity included garner or conditioning bins which could be utilized as storage space only during a part of the season; and (3) the fact that individual small lots were stored in separate large volume bulk bins. Because all drying must be completed before the garner or conditioning bins are available for storage, it was impossible for drier-storage units to utilize completely all available bulk storage space, even with unlimited demand for storage. Also, since the relative price of rough rice is determined largely by the variety, grade, and head-rice yield, some bulk bin capacity was unused when small lots of a given variety, grade, and head-rice count owned by an individual producer did not utilize the full capacity of a bin. Some of the cooperative storage units in Arkansas solved this problem by the practice of commingling the lots in storage, thus accounting for their higher indicated utilization of available capacity. But this practice was not common in other areas. Producers not connected with a cooperative rice mill, and not receiving a blend price, objected to commingling in bulk storage because commingling by variety and grade still did not solve the problem of variations in head-rice yield from lot to lot. Furthermore, the danger existed that they would obtain a lower price for their product than could be obtained if each lot were stored separately.

Businesses that operated both bulk and flat storage in connection with rice driers had a larger capacity and a larger volume stored per unit than the other types of businesses. These units had an average capacity 134,000 hundredweight per business and a volume stored of 100,000 hundredweight in the 1951-52 season. Units with bulk storage only and driers averaged about 61 percent of their level of capacity and about 69 percent of the volume stored; units that operated with flat storage and without driers had a capacity and volume stored of 40 and 42 percent, respectively, of the level of those operating with both bulk and flat warehouse storage and driers.

Among the different States, the capacity per business for the units with driers and both types of storage was about 20 percent higher in Texas than in Louisiana, and Texas stored in this type of unit about 15 percent more rice per unit. For those operating with driers and bulk storage only, the businesses in Arkansas had a volume averaging 60 percent greater than similar units in Texas, while they stored more than twice as much rice in units of that type during the same period. Considering that, in general, the Louisiana units are the oldest, the Texas units second, and the Arkansas

Table 5.-- Rated storage capacity and volume of rough rice stored, 63 rough rice storage units in different regions, Southern Rice Area, 1951-52 storage season

Type of unit	Volume per unit									
	Louisiana		Texas		Arkansas and Mississippi		Average			
	Rated : storage : capacity :	Volume : stored : 100 lbs. :	Rated : storage : capacity :	Volume : stored : 100 lbs. :	Rated : storage : capacity :	Volume : stored : 100 lbs. :	Rated : storage : capacity :	Volume : stored : 100 lbs. :	all units	Volume : stored : 100 lbs. :
Bulk and flat storage with drier:										
Bulk storage ...	56,753	49,473	79,999	50,506	(1/)	(1/)	71,418	50,073		
Flat storage ...	60,615	44,769	70,543	59,057	(1/)	(1/)	62,684	49,834		
Total	117,368	94,242	150,542	109,663	(1/)	(1/)	134,102	99,907		
Bulk storage only with drier.....	(1/)	(1/)	55,485	37,117	91,975	85,049	81,356	68,599		
Bulk and/or flat storage without drier:										
Bulk storage ...	2,754	2,511	42,120	23,490			9,180	6,008		
Flat storage ...	53,298	43,376					44,416	36,149		
Total	55,952	45,887	42,120	23,490			53,596	42,157		
Average, all units	89,832	72,348	103,926	73,768	96,607	87,666	96,163	76,292		

1/ Less than 2 units.

units the most recently constructed, the trend appears to be toward construction of larger volume units of each type than was true 10 to 20 years ago.

In Louisiana, most of the flat storage units were without driers. These businesses had a storage capacity and volume stored averaging only about half the capacity and volume of the units operated in connection with driers in Louisiana and in other States. However, the flat warehouse storage units made just as full utilization of available storage capacity as any other type of storage unit. As most of these units were in Louisiana where bulk storage capacity is relatively small, full utilization of such capacity is less likely to occur if additional bulk facilities become available in this region.

An indication of the season-to-season effects of variations in production and in market demand on the quantity of rough rice stored is shown in table 6. Of the 24 units operating driers with both flat and bulk storage, 22 were in operation the previous season and 19 operated in the 1949-50 season. The volume stored varied from about 77,000 hundredweight per unit in the 1949-50 season to 72,000 hundredweight in 1950-51 and 100,000 hundredweight in 1951-52. Similar variations were indicated for the other types of storage units. In general, rice moved to mills more rapidly in the 1950-51 season than in the other two years, resulting in relatively low need for storage capacity. Despite the fact that the 1949-50 season produced a much lower total rice yield than the more recent 1951-52 period, the rough rice stored per unit was about the same for most types of storage facilities. This was due to a relatively slow movement of rough rice to the mills in 1949-50. In view of the increased total production since 1949-50, a marketing season similar to or slower than that year could cause storage difficulties in some areas.

Capital valuations:

Four different capital figures were obtained from each cooperating business: (1) The original cost when constructed, or when purchased, plus the cost of capital improvements, when made since that time; (2) the depreciated value as established for income-tax purposes at the end of the 1951-52 storage season; (3) the estimated market value at the end of the 1951-52 storage season; and (4) the estimated replacement cost.

The original cost and the depreciated value or "book value" can be considered accurate since adequate records on these items were available from all cooperators. The replacement cost was an estimate made by the manager of each business, but can be considered reasonably accurate since 1951-52 construction costs for buildings and the purchase price of equipment were known by most cooperators. The estimation of market value, however, was more difficult to obtain and cannot be considered as accurate as the other estimations.

Table 6.- Trends in storage operations of rough rice storage units in the Southern Rice Area, 1949-50 to 1951-52 storage seasons

Type of unit	Storage season					
	1951-52		1950-51		1949-50	
	Storage	Volume	Storage	Volume	Storage	Volume
	units	per unit	units	per unit	units	per unit
	Number	pounds	Number	pounds	Number	pounds
Bulk and flat storage with drier:						
Bulk storage - - - -	24	50,073	22	32,748	19	30,543
Flat storage - - - -	24	49,834	22	39,251	19	46,630
Total - - - - -	---	99,907	---	71,999	---	77,173
Bulk storage only with drier - - - - -	27	68,599	25	59,496	18	65,322
Bulk and/or flat storage without drier:						
Bulk storage - - - -	12	6,008	10	486	8	---
Flat storage - - - -	12	36,149	10	31,914	8	43,740
Total - - - - -	---	42,157	---	32,400	---	43,740
Total units and average weight per unit - - - -	63	76,292	57	59,567	45	66,490

Theoretically, market value is nothing more than a capitalization of expected returns, but it was found that the cooperating rice storage operators considered the market value of their facilities as the price which a purchaser would pay in a non-distress sale. Thus, the market value was reported on the basis of certain considerations which a prospective buyer might have in mind, such as: (1) Expected returns; (2) alternative uses of his capital; (3) if a producer, the possibility of obtaining rice drying and storage facilities; (4) if a miller, the possibility of storing additional supplies for the purpose of increasing mill volume; (5) the complementary effects of the facilities on other business enterprises, such as feed, fertilizer, and equipment sales; and (6) the intangible value of owning and operating a rice storage unit.

It is to be noted that there is also a marked tendency to estimate the market value on the basis of the more recent, or current returns, or in the light of current replacement costs. Thus, to the extent that current returns, or returns in the immediate past, and estimated replacement costs are not representative of long-time conditions in the industry, market values so derived are inaccurate. Because of these factors, the market value estimations were considered relative rather than absolute expressions.

The average valuations per unit by each of the four capital evaluation bases used in this study for the five different types of businesses covered in the sample are presented in table 7.

Table 7.- Total capital valuations of 63 rough rice storage units, Southern Rice Area, 1951-52 storage season

Type of unit	Value per unit for buildings and equipment			
	Original	Depreciated	Market	Replacement
	cost	value	value	cost
	1952	1952	1952	1952
	Dollars	Dollars	Dollars	Dollars
Bulk and flat storage	:	:	:	:
with drier - - - - -	215,234	161,180	233,062	256,902
Bulk storage only with	:	:	:	:
drier - - - - -	209,748	168,706	212,049	256,231
Flat storage only	:	:	:	:
without drier - - - -	45,375	22,842	55,000	81,250
Bulk storage only	:	:	:	:
without drier - - - -	63,000	59,850	63,000	73,750
Bulk and flat storage	:	:	:	:
without drier - - - -	105,580	95,022	114,000	118,000
Average, all units	191,200	148,811	200,261	230,201

For all units studied, the original cost averaged \$191,200; the depreciated value in 1952 was \$148,811; the market value in 1952 was \$200,261, and the estimated replacement cost averaged \$230,201 per unit. Valuations varied greatly according to the type of business. In general, the facilities operated in connection with driers, whether both bulk and flat storage or bulk storage alone, had about the same values per unit, varying from about \$160,000 as the depreciated value to \$256,000 per business as the replacement cost. Units operating as flat storage only, without driers, had depreciated values less than half the original cost, indicating the relative age of these facilities. Units operating without drier facilities had capital valuations that were only a fourth to a third as large as those with both storage and drying services.

Only about half the businesses studied had sufficiently detailed records to permit an accurate division between the capital values of land, buildings, and equipment used for storage and the capital values used for drying and other business services. Based on the data available, and applying the ratio of "capital values for storage to total capital" to all units, an estimate of the average capital valuations for storage purposes only is shown in table 8. For the units operating driers along with storage facilities, about a third of the total capital was considered investment in the drier and drier equipment and two-thirds in storage facilities.

Table 8.- Capital valuations for storage facilities only, 63 rough rice storage units, Southern Rice Area, 1951-52 storage season

Type of unit	Value per unit of buildings and equipment used for storage			
	Original	Depreciated	Market	Replacement
	cost	value	value	cost
	1952	1952	1952	1952
	Dollars	Dollars	Dollars	Dollars
Bulk and flat storage	:	:	:	:
with drier - - - - -	136,027	101,866	147,295	162,362
Bulk storage only with	:	:	:	:
drier - - - - -	157,940	127,036	159,673	192,942
Flat storage only	:	:	:	:
without drier - - - -	45,375	22,842	55,000	81,250
Bulk storage only	:	:	:	:
without drier - - - -	63,000	59,850	63,000	73,750
Bulk and flat storage	:	:	:	:
without drier - - - -	105,580	95,022	114,000	118,000
Average, all units	131,732	98,852	131,641	160,946

Although these data provide some indication of capital values for storage, they should be considered only approximations because of the difficulty, even with the most accurate accounting system, of identifying and separating storage facilities from drying and other facilities. This is due to the fact that many facilities are used interchangeably for both purposes. This includes the bulk garner bins, the conveyers, loading and weighing equipment, and similar items.

Capital values of storage facilities per unit of storage capacity are presented in table 9. The averages for the 63 units studied were: \$1.03 per hundredweight storage capacity for the depreciated value in 1952; \$1.37 per hundredweight for the 1952 market value; and \$1.67 per hundredweight for the 1952 replacement cost.

Capital values per unit of storage varied according to the type of business. The flat warehouse storage units without driers had values per storage capacity of only about half the other types. The most significant capital valuation, the market value in 1952, varied from \$0.96 per hundredweight for flat storage units without driers to \$1.10 per hundredweight for bulk and flat storage units with driers; \$1.52 for bulk storage units without driers; \$1.96 for bulk storage units with driers; and \$2.23 for bulk and flat storage units without driers.

Table 9.- Capital valuations for storage facilities per unit of storage capacity, 63 rough rice storage units, Southern Rice Area, 1951-52 storage season

Type of unit	: Storage : capacity : per unit	: Capital values per Cwt. storage capacity			
		: Original	: Depreciated	: Market	: Replacement
		: cost	: value	: value	: cost
	: Cwt.	: Dollars	: Dollars	: Dollars	: Dollars
Bulk and flat storage	:	:	:	:	:
with drier - - - -	: 134,102	: 1.01	: 0.76	: 1.10	: 1.21
Bulk storage only with:	:	:	:	:	:
drier - - - -	: 81,356	: 1.94	: 1.56	: 1.36	: 2.37
Flat storage only	:	:	:	:	:
without drier - - -	: 57,510	: .79	: .40	: .96	: 1.41
Bulk storage only	:	:	:	:	:
without drier - - -	: 41,310	: 1.52	: 1.45	: 1.52	: 1.78
Bulk and flat storage	:	:	:	:	:
without drier - - -	: 51,030	: 2.07	: 1.36	: 2.23	: 2.31
Average, all units	: 96,163	: 1.37	: 1.03	: 1.37	: 1.67

These facts indicate that per unit of storage capacity, the old-type flat warehouse facility is still the most economic unit from the standpoint of capital investment. However, as indicated in the section on costs and returns, this reduced cost is largely offset by higher operating costs, especially for labor, of the flat warehouses. The investment figures also show that, per unit of capacity, storage facilities established in connection with driers are more efficient from the standpoint of capital costs than similar facilities established without a drier. This is due to the possibility of multiple use of many facilities when operated in connection with a drier. Since the drier and bulk facilities are usually housed in the same building, and the conditioning or garner bins are also used for storage bins, the investment cost for storage bins is reduced. Also, since the conveyers and the conveyer system are used to move rice to and from the drier, as well as to and from the storage units, this multiple use reduces the per unit investment cost of storage equipment.

An attempt was made to analyze the records collected according to the type of storage buildings. Flat storage warehouses were commonly built of corrugated metal or of wood. Bulk storage facilities were usually constructed of corrugated metal or of concrete. Because so many of the businesses studied had several kinds of buildings without accurate records of costs and depreciation for each type, and because the larger bulk storage units tended to be of concrete construction, while most of the smaller ones were of corrugated metal, no significant results were obtained from this analysis. For bulk storage, corrugated metal buildings appeared to have capital costs from 10 to 20 percent higher per unit of storage than concrete buildings. However, because small concrete units could not be economically constructed, two-thirds of all bulk storage facilities studied were built of corrugated metal rather than concrete. For flat warehouse storage, about 60 percent of all such facilities were built of corrugated metal and 40 percent of wood. The flat warehouses built of wood had investment costs per unit of capacity from 20 to 50 percent higher than similar facilities constructed of corrugated metal. However, some of the cooperators said that more adequate, safer storage was possible in wooden warehouses than in metal units because of the greater heat conductivity of metal.

Although commonly the concrete bulk storage facilities were initially more expensive per unit of capacity, the indicated depreciation rates revealed an expected life of about 50 years as compared with 20 to 30 years for metal bulk facilities. Similarly, flat wooden warehouses were more expensive to construct but were estimated to last from 30 to 40 years, while the flat metal warehouses were expected to be completely depreciated in 20 to 30 years. These differences in depreciation appear to offset to a large extent the variations in investment per unit of capacity. Assuming the availability of sufficient capital, it appears from these facts that the decision as to the kind of storage building depends largely on the type that is best adapted to the volume expected and that will do the best job of efficient storage under prevailing local conditions.

Costs and Returns from the Operation of Commercial Rice Storage Units

Most of the commercial rice storage units surveyed in the Southern Rice Area for the 1951-52 storage season were multiple-purpose enterprises. For units operating rice driers in connection with storage operations, which included about 80 percent of the total sample, rice drying accounted for most of the expenses and income. The majority of these units also operated farm supply businesses, which included selling feed, seed, and equipment. In addition, many units supplied other services to producers such as seed rice cleaning, seed treatment, and the like.

Expenses:

For all units studied, total expenses averaged \$67,100 per business (table 10). This included \$18,782 for direct labor and management, \$29,063 for operating costs during the season, and \$19,255 for all overhead charges.

Table 10.- Costs and returns from the operation of 63 rough rice storage units, Southern Rice Area, 1951-52 storage season.

Item	Amount per unit									
	Bulk & flat storage	Bulk storage	Sack storage	Bulk storage	Bulk & sack storage	Average, all				
	storage with drier	storage only with drier	storage only without drier	storage without drier	storage without drier	storage all units				
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars				
Costs:										
Labor & management										
Direct labor.....	20,893	12,025		8,037	775		8,935		14,674	
Office and management.....	6,239	3,517		1,812	---		5,245		4,108	
Total.....	27,132	15,542		9,849	775		14,180		18,782	
Operating costs:										
Purchases for resale.....	31,139	3,022		33,167	---		25,859		18,190	
Elec. & fuel.....	3,985	4,280		297	37		273		3,400	
Insect control.....	151	71		126	88		---		107	
Misc. costs.....	12,456	5,339		1,940	170		2,527		7,366	
Total.....	47,731	12,712		35,530	295		28,659		29,063	
Overhead costs:										
Repairs.....	3,774	2,508		406	1,000		1,338		2,607	
Interest paid.....	2,631	2,301		375	---		1,503		2,084	
Insurance.....	6,208	3,065		1,298	3,636		4,114		4,029	
Taxes.....	1,646	992		513	54		589		1,152	
Depreciation.....	14,388	10,261		1,454	3,150		3,519		9,383	
Total.....	28,647	19,127		4,046	7,840		11,063		19,255	
Total costs	103,510	47,381		49,425	8,910		53,902		67,100	
Returns:										
Rough rice storage..										
Rice drying.....	14,400	8,245		6,680	6,075		14,399		10,518	
Merchandise sales...	57,972	45,742		---	---		---		41,688	
All other income....	37,034	3,340		37,778	---		29,399		21,268	
Total income.....	11,354	725		7,812	---		16,112		6,139	
	120,760	58,052		52,270	6,075		59,910		79,613	
Net income	17,250	10,671		2,845	- 2,835		6,008		12,513	

Direct labor charges accounted for more than 80 percent of all labor and management costs. Of the operating costs, supplies bought for resale amounting to \$18,190 per unit made up the major item. This item was more than offset by the income received from sales of \$21,268, which resulted in a gross margin of \$3,078 per business for this phase of the operations. Of total overhead charges, depreciation accounted for almost half.

Costs varied widely for the different types of business. Units operating both bulk and flat warehouse storage in addition to drying operations had total costs about twice the level of the other types of businesses. This was due primarily to a larger volume of storage and drying, a relatively large farm supply operation, and higher overhead costs because of the size of the business. On the average, units operating bulk storage only with driers, those operating as sack storage only without driers, and those operating as both bulk and sack storage without driers had approximately the same total costs per unit. However, a much larger part of total costs for the bulk storage units with driers was made up of labor expenses and depreciation; a smaller proportion of the total included supplies for resale. In contrast to the other types of business, units operating as bulk storage only with driers specialized almost completely in the drying and storage of rice. A similar picture was indicated by the expenses of the units operating as bulk storage only without driers. These businesses were relatively small and were operated solely for rough rice storage.

The tendency for the units having bulk storage only to specialize in rice storage and drying to the exclusion of other enterprises is due to the nature of the facilities and the origin of these businesses. Bulk storage facilities are not well adapted for storing and handling farm supplies, cleaning rice seed, and the like. Also, most of the bulk storage businesses are of recent origin while those with both bulk and flat warehouses are older and were originally established for multiple-purpose use.

Cost of depreciation was a major item for all units, as indicated in table 11. For all units, the estimated average expected life of the total investment in buildings and equipment was 20.4 years, the age at the end of the 1951-52 season was 4.5 years, and the average annual depreciation was \$9,383 per unit.

The combined average length of expected life for buildings and equipment of 20.4 years represents driers and drier equipment, accounting for about a third of the investment, with an average life of about 10 years; other equipment, accounting for about 10 percent of the total, with an average life of 5 to 10 years; and buildings, accounting for more than half of the total, having an estimated average life varying from 25 to 50 years. The average age at the end of the 1951-52 season represents the length of time the property has been in the hands of the present owners, as depreciation is computed on the purchase price or construction cost. In some cases, where the property had changed hands after a number of years, the actual age was much greater than the age indicated at the end of the 1951-52 season by the depreciation determinations for income-tax purposes.

Table 11.- Depreciation costs for 63 rough rice storage units, Southern Rice Area, 1951-52 storage season

Type of business	Depreciation for buildings and equipment				
	Average	Age at	Total	Depreciation	
	length of	end of	depreciation	1951-52	
	expected	1951-52	to date	season	
	life	season			
	Years	Years	Dollars	Dollars	
Bulk and flat storage					
with drier - - - - -	15.0	3.8	54,054	14,338	
Bulk storage only					
with drier - - - - -	20.4	4.0	41,042	10,261	
Sack storage only					
without drier - - - -	31.2	15.5	22,533	1,454	
Bulk storage only					
without drier - - - -	20.0	1.0	3,150	3,150	
Bulk and sack storage					
without drier - - - -	30.0	3.0	10,558	3,519	
Average, all units	20.4	4.5	42,389	9,383	

The average age of the facilities at the end of the 1951-52 season, however, does provide an indication of the relative differences in the time of establishment. Units operating as flat storage only, without driers, had an average age of 15 years, while most of the other types of business averaged 3 to 4 years.

Gross and net income:

For all units studied, total gross income amounted to \$79,613 per business. Of this income, about 52 percent was from drying charges, 27 percent from merchandise sales, 13 percent from rice storage, and about 8 percent from other sources such as seed cleaning, seed treatment, and the like. Net income after deducting all costs amounted to \$12,513 per unit.

The gross income of the units operating bulk and flat storage as well as driers was about double that of most of the other business groups. The net income of the different business types varied from \$17,250 per unit for the bulk and flat storage units with driers to \$10,671 for the bulk storage units with driers, \$6,008 for the bulk and flat storage units without driers, and \$2,845 for the flat storage units without driers, but a loss of \$2,835 was reported by the bulk storage units without driers.

These variations in net income indicate the importance of the multiple-unit operations of most rice storage and drying businesses. Net income varied directly with the number and volume of other services supplied by rough rice storage units. Businesses having both bulk and flat storage, drying facilities, supplies for sale, and offering other needed services to farmers had the highest net income. As the number and volume of the different services decreased, the average net income decreased. Businesses operating only bulk storage, without additional services, did not have total income sufficient to pay all costs.

Returns to capital:

The net income returns per unit as expressed in table 11 indicate the actual net income according to usual accounting procedures, including the actual interest costs paid by the different businesses for the use of borrowed funds invested in the business. Because two firms seldom have the same relative investment in borrowed funds and are not likely to have the same interest costs, comparisons of actual interest costs between different units or different groups of units may be unreliable. For such comparisons, a more accurate picture of true returns in relation to the total capital invested is possible if the actual interest costs are ignored and computed interest costs are established based on the total capital invested in the business and the prevailing interest rate for borrowed funds. This approach places all firms on the same basis in regard to capital charges.

Such a comparison is presented in table 12. In this determination, three different capital values were used; (1) The depreciated value for income-tax purposes at the end of the 1951-52 season; (2) the market value of total assets at the end of the season; and (3) the replacement value. In terms of the most realistic measure of net income for the owners of capital now invested in these businesses, the return after deducting a reasonable interest charge on the depreciated capital value is probably most reasonable since it provides them with a result they can compare with other alternative uses of their capital. In terms of actual net income to be expected if ownership were transferred at the current market values, the net income after deducting interest on the market value of the investment in the business is most accurate. In terms of the probable costs to the industry if additional facilities are needed, the net income after deducting interest on the replacement value of the investment is the most reasonable basis of measurement.

An arbitrary rate of 5 percent was used as the going rate of interest in the region for reasonably stable long-time investments. This rate may not be correct for all individuals and it can be changed, if desired, in making specific evaluations or comparisons. The relative differences, however, will remain approximately the same regardless of the interest rate used so long as it is applied to the total investment in the business.

On these bases, the net income per business studied varied from \$12,513 when actual interest costs only were considered, to \$7,157 when interest

Table 12.- Returns to various measures of capital investment, 63 rough rice storage units, Southern Rice Area, 1951-52 storage season.

Measures of capital investment	Bulk & flat:		Bulk		Flat		Bulk		Bulk & flat:		Average,
	storage	with	storage	only with	storage	only with	storage	only with	storage	without	
	drier	drier	drier	drier	drier	drier	drier	drier	drier	drier	units
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Costs:											
Labor and management	27,132		15,542		9,849		775		14,180		18,782
Operating expenses	47,731		12,712		35,530		295		28,659		29,063
Overhead costs, excluding interest.	26,016		16,826		3,671		7,840		9,560		17,171
Total costs, excluding interest	100,879		45,080		49,050		8,910		52,399		65,016
Total returns	120,760		58,052		52,270		6,075		59,910		79,613
Net operating income before interest	19,881		12,972		3,220		2,835		7,511		14,597
Interest costs:											
Actual	2,631		2,301		375		—		1,503		2,084
Computed on depreciated value $\frac{1}{2}$..	8,059		8,435		1,142		2,988		4,751		7,440
Computed on market value $\frac{1}{2}$	11,653		10,602		2,750		3,150		5,700		10,013
Computed on replacement value $\frac{1}{2}$..	12,845		12,812		4,062		3,688		5,900		11,510
Net income:											
Actual	17,250		10,671		2,845		2,835		6,008		12,513
Interest costs on depreciated value:	11,822		4,537		2,078		5,823		2,760		7,157
Interest costs on market value	8,228		2,370		470		5,985		1,811		4,584
Interest costs on replacement value:	7,036		160		842		6,523		1,611		3,087
Net operating income in percent of total assets:											
Based on depreciated value of assets:	12.3		7.7		14.1		4.7		7.9		9.8
Based on market value of assets	8.2		6.1		5.9		4.5		6.6		7.3
Based on replacement value of assets:	7.7		5.1		4.0		3.8		6.4		6.3

$\frac{1}{2}$ Computed at 5 percent of the ending inventory value of buildings and equipment.

charges of 5 percent of the depreciated capital value were assessed; \$4,584 when similar interest costs were based on the market value of capital invested in the business, and only \$3,087 with interest charges based on the replacement value. In general, when the standard interest charges were applied, the firms in each operational group had rapid declines in computed net income below the actual net income received.

If all interest charges are eliminated, including the actual interest paid, and the net operating income before interest is determined, a measure of return reflecting the actual earnings on invested capital may be obtained. This determination is presented in table 12. The average net operating income of all units studied in percentage of total assets when based on depreciated value of assets was 9.8 percent; when based on the market value of total assets, 7.3 percent; and only 6.3 percent when calculated on the basis of the replacement value of investments in the business. Firms operating flat storage units only without driers had the greatest variation in returns when the different investment values were considered. These businesses averaged 14.1 percent net income on the depreciated capital investment, but only 5.9 on the market value of assets and 4.0 on the replacement cost basis. This variation was due to the fact that the depreciated value of assets for the older units was so much less than the current market value and replacement value of the buildings and equipment used in the business.

This analysis indicates several significant points regarding the operation of multiple-purpose rice storage units in the Southern Rice Area. Based on the actual depreciated investments in the businesses, returns in the 1951-52 season approximating 10 percent on the investment were reasonably good. Returns based on the market value of assets and on the replacement value, however, were not high. Figures for several years are needed before costs and returns for use in establishing long-time trends can be determined. But if the 1951-52 results are representative of conditions over a period of time, investments in storage facilities for rough rice should be made with caution because the returns on 1952 replacement and market values were not sufficiently high to offset many unfavorable years.

The returns were high enough, however, to justify multiple-purpose storage units for rough rice when a sufficient volume was available to justify it and when the businesses could operate supplementary enterprises to reduce costs and utilize all facilities.

The facts also indicate that in the event expanded storage facilities are needed, such facilities may be slow to become established. Many businessmen will be reluctant to make extensive investments with an expected return of only about 6 percent before interest and State and Federal income taxes, when interest costs may amount to almost as much as the expected return. This illustrates the need for adequate long-time financing adapted to the requirements of the industry, if additional facilities are to be established. The problem of expanding facilities beyond current levels in view of the costs of building new facilities at the indicated levels is further complicated by the ever-present threat of acreage allotments and

marketing quotas for rice. These could reduce the volume produced to the point that even the existing facilities would have serious difficulties because of a smaller volume available for storing, drying, and handling in other ways.

Costs and returns from storage operations:

Because the typical rough rice storage business in the Southern Rice Area was a multiple-purpose firm, accurate data on actual costs and returns from the storage operation, distinct from the remainder of the business operations, was not obtained. Although storage costs alone could be determined by a detailed cost accounting approach, such an analysis was beyond the scope of this study. Even if such data were available, it would probably be of doubtful value because storage income made up only 13 percent of the gross income of the units surveyed.

However, a rough approximation of storage costs in relation to storage income has been made. The businesses surveyed did not keep sufficient records to break down operating costs other than labor and overhead costs according to the different business endeavors, but the operators provided a rough estimate of the proportion of direct labor costs which they thought should be charged to storage. If it is assumed that the ratio of all storage costs to all expenses is the same as the ratio existing between all labor costs for storage and total labor costs, an estimate of actual storage costs in relation to storage income can be determined. For all units studied, an average of 20 percent of the labor costs was allocated to storage operations.

Using the proportion of labor costs for storage to total labor costs for each group of businesses, and applying this ratio to the total expenses, an estimate of storage costs as compared with storage returns is shown in table 13. On this basis, the average net income from storage operations for all firms studied was \$822 per unit. The units operating driers made a net income of less than \$1,000 per business, while those depending more on storage than on other enterprises had higher returns from the storage operation.

It appears from this analysis that the larger multiple-purpose units depending upon storage income for only a small part of the total earnings maintained the storage enterprise primarily on a cost-covering or service basis in order to obtain the income from the more profitable drying, seed cleaning, and other similar enterprises. The businesses without driers which depended on storage income for a larger part of gross receipts apparently operated the storage enterprise as the major profit-producing effort.

This observation is illustrated more clearly by a comparison of per unit costs and returns from the storage operation. The 24 firms operating both bulk and flat storage warehouses in addition to driers and other supplementary enterprises had computed storage costs of 13.7 cents per hundredweight of rough rice stored compared with storage income of 14.4 cents,

resulting in a net income from storage of about three-fourths of 1 cent per hundredweight stored. The 27 units operating bulk-storage facilities only, together with driers and other enterprises, had storage costs of 10.9 cents per hundredweight stored and storage income of 12.0 cents, or a net income from storage of about 1 cent per hundredweight stored. The 8 units having flat storage only without a drier enterprise had storage costs of 12.1 cents per hundredweight as compared with storage income of 15 cents, resulting in a net income from storage of about 3 cents per hundredweight.

Table 13.- Costs and returns from storage operations, 63 rough rice storage units, Southern Rice Area, 1951-52 storage season

Items of cost and return	Amount per unit					
	Bulk	Bulk	Bulk	Bulk	Bulk	Average, all units
	and flat:	and flat:	and flat:	and flat:	and flat:	
	storage with drier	storage with drier	storage with drier	storage with drier	storage with drier	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Total costs:	:	:	:	:	:	:
Labor & management	27,132	15,542	9,849	775	14,180	18,782
Operating costs - -	16,592	9,690	2,363	295	2,800	10,873
Overhead costs - - -	28,647	19,127	4,046	7,840	11,063	19,255
Total - - - - -	72,371	44,359	16,258	8,910	28,043	48,910
Income:	:	:	:	:	:	:
Rough rice storage	14,440	8,245	6,680	6,075	14,399	10,518
Rice drying - - - -	57,972	45,742	---	---	---	41,688
Gross margin on merchandise sales	5,895	318	4,611	---	3,540	3,078
Other income - - - -	11,354	725	7,312	---	16,112	6,139
Total - - - - -	89,612	55,030	19,103	6,075	34,051	61,423
Net income from all operations - - -	17,250	10,671	2,845	-2,853	6,008	12,513
Percentage total costs:	:	:	:	:	:	:
charged to storage	18.9	16.9	33.2	100.0	33.0	19.8
Storage costs -dollars:	13,678	7,497	5,397	8,910	9,254	9,696
Storage income	:	:	:	:	:	:
dollars:	14,440	8,245	6,680	6,075	14,399	10,518
Net income from storage operations	:	:	:	:	:	:
dollars:	762	748	1,283	-2,853	5,145	822

The major reason for the lower costs per unit for the flat storage units without driers was the relatively low overhead cost because most of these units were 10 to 30 years old and had been built when construction costs were low. If reasonable interest and depreciation charges, based on the market value or replacement value of assets, are added to their costs, the cost per unit stored becomes approximately the same as for the other more recently constructed storage businesses.

Variations in costs by differences in storage capacity:

A detailed analysis of differences in costs and returns from the rough rice storage operation according to size of business was not possible because: (1) The sample was too small and varied to provide significant results; (2) the storage operation represented only 13 percent of the average gross income per firm, and the volume of rice dried, cleaned, sacked, and treated, as well as the volume of merchandise sold, was more important in affecting costs and returns than the volume of rough rice stored; and (3) the firms studied varied so widely as to types of operations and functions.

An attempt was made to obtain an indication of the effects of volume of rice stored on costs and returns for both the entire business and the storage function, for the two groups of units where the sample was sufficiently large to obtain some statistical reliability. These were the units operating bulk and flat storage with driers and other operations, of which there were 22 records with sufficient detail for a volume analysis, and the units operating only bulk storage with driers and other operations, of which there were 25 records with sufficient detail for a volume analysis. But this analysis should be considered only an approximation, because of the wide variation in practices for the small sample in each case; the fact that storage capacity does not necessarily indicate the true volume of business as this volume was more greatly affected by the volume dried and the extent of merchandise sales; and the apparent tendency of some units to use the storage function as a "loss leader" in order to obtain the more profitable drying and other types of business.

A comparison of the low storage capacity units with those of larger storage capacity for the units with both bulk and flat storage with driers, and those with bulk storage only with driers, is presented in table 14.

In general, storage capacity was related to other business functions. For the bulk and flat storage units with driers, the total income of those with less than 100,000 hundredweight of storage capacity was only about one-third of the total income of the units having 100,000 hundredweight of storage capacity or more. A similar relationship was indicated for units having bulk storage only with driers.

For units having both bulk and flat storage, those with the smaller storage capacity had a net income from all operations amounting to \$5,590 per unit, which was only about one-fourth the net income per unit of those

Table 14.- Costs and returns for rough rice storage units operated with driers, according to storage capacity, Southern Rice Area, 1951-52 storage season.

	: Bulk & flat storage		: Bulk storage only	
	: Less than : 100,000 cwt.		: Less than : 80,000 cwt.	
	: 100,000 : or		: 80,000 : or	
	: cwt. : more		: cwt. : more	
	: capacity	: capacity	: capacity	: capacity
	: Dollars	: Dollars	: Dollars	: Dollars
Costs, per storage unit:				
Labor & management	12,823	38,057	8,792	26,732
Operating costs ^{1/}	6,376	12,342	5,745	11,002
Overhead costs ^{2/}	19,297	44,084	16,856	38,243
Total	38,496	94,483	31,393	75,977
Income:				
Rough rice storage	7,168	20,452	3,266	15,788
Rice drying	32,822	77,049	32,629	62,701
Gross margin on merchandise sales	1,872	9,607	—	1,943
Other income	2,224	10,596	868	663
Total	44,086	117,704	36,763	81,095
Net income from all operations	5,590	23,221	5,370	5,118
Percentage of total costs charged to storage	18.6	19.2	14.8	19.2
Storage costs ... Dollars	7,160	18,140	4,646	14,588
Storage income .. Dollars	7,168	20,452	3,266	15,788
Net income from storage operations.....				
Dollars	8	2,312	- 1,380	1,200
Cost per cwt. stored.....				
Cents	16.6	12.4	21.3	10.5
Income	16.6	14.0	15.0	11.3
Net return	0.0	1.6	- 6.3	0.8
Storage capacity .. cwt.	59,424	187,529	41,600	151,975
Volume stored cwt.	43,194	145,811	21,762	139,511
Book value of assets ..				
Dollars	104,810	208,155	87,837	299,581
Number of units	10	12	15	10

^{1/} Not including costs of merchandise purchased for resale.

^{2/} Including repairs, insurance, taxes, depreciation, and interest computed at 5 percent of the book value of all assets used in the business.

with the larger storage capacity. However, for the two different capacity groups among the units operating bulk storage only with driers the net income from all operations was about the same. Although the smaller volume units only stored an average of 21,762 hundredweight of rough rice in a warehouse capacity of 41,600 and had an income from rice storage only about one-fifth as high as those with higher storage capacity, their income from rice drying was more than half the drying income from the units with larger storage capacity.

In terms of costs and returns to the storage function, the higher volume units in both groups had lower costs per 100 pounds stored and higher net returns per hundredweight stored. As indicated by the net income from all operations conducted by the two groups, however, low costs and high net returns from the storage operation did not necessarily mean low costs and high net returns from the entire business.

Variations in Costs by Differences in Utilization of Storage Capacity

A detailed analysis of differences in costs and returns according to variations in utilization of storage capacity was not possible for the same reasons presented in the discussion relative to volume or storage capacity. However, an attempt was made to obtain an indication of the effects of the utilization of storage capacity on costs and returns. This analysis should be considered an approximation rather than an absolute indication for the reasons indicated heretofore.

Table 15 presents a comparison of relative costs and returns for units utilizing less than 75 percent of available storage capacity and those utilizing 75 percent or more, for (1) those business groups operating with both bulk and flat storage with driers, and (2) those operating only with bulk storage and driers.

For units with both bulk and flat storage with driers, those with a utilization of storage capacity of 75 percent or more had a net income per firm from all operations which was more than three times as great as units that utilized less than 75 percent of their storage capacity. However, among the units operating with bulk storage only with driers, those with the lower storage capacity had the highest net returns. This was apparently due to the fact that units with lower utilization of storage capacity held their stored rice for a longer period of time, and thus received a higher income per unit stored and had a relatively efficient drying operation.

In terms of costs and returns to the storage function, low costs per unit stored and high net returns per unit were directly related to utilization of storage capacity. Bulk and flat units with driers and units with bulk storage only with driers that utilized 75 percent or more of their total storage capacity had storage costs of 12 and 9 cents per hundredweight, respectively, as compared with costs varying from 18 to 21 cents per hundredweight for those with lower utilization of storage capacity.

Table 15.- Costs and returns for rough rice storage units operated with driers, according to the proportion of total storage capacity utilized, Southern Rice Area, 1951-52 storage season

	Bulk & flat storage		Bulk storage only	
	Less than 75% of capacity used	75% or more of capacity used	Less than 75% of capacity used	75% or more of capacity used
	Dollars	Dollars	Dollars	Dollars
Costs per storage unit:				
Labor and management ...	25,666	27,692	13,124	20,218
Operating costs 1/	10,562	8,584	7,912	7,708
Overhead costs 2/	30,871	37,868	23,000	29,368
Total	67,099	74,144	44,036	57,294
Income:				
Rough rice storage	10,509	19,200	5,033	13,114
Rice drying	52,812	61,904	43,183	46,628
Gross margin on merchandise sales	4,061	7,528	572	1,086
Other income	6,355	8,209	1,112	278
Total	73,737	96,841	49,900	61,106
Net income from all operations	6,638	22,697	5,864	3,812
Percentage of costs for storage	16.4	22.0	14.6	19.5
Storage costs .. Dollars	11,004	16,312	6,429	11,172
Storage income .. Dollars	10,509	19,200	5,033	13,114
Net income from storage operations Dollars	- 495	2,888	- 1,396	1,942
Cost per cwt. stored				
Cents	18.0	11.3	20.8	8.9
Income per cwt. stored ..				
Cents	17.2	13.2	16.3	10.4
Net return per cwt. Cents	- 0.8	1.9	- 4.5	1.5
Storage capacity .. cwt.	117,203	144,265	63,052	119,493
Volume stored cwt.	60,990	144,976	30,940	125,583
Book value of assets				
Dollars	127,216	202,231	139,511	221,380
Number of units	12	10	15	10

1/ Not including costs of merchandise purchased for resale.

2/ Including repairs, insurance, taxes, depreciation, and interest computed at 5 percent of the book value of all assets used in the business.

Full utilization, however, was obtained at the sacrifice of a lower income per hundredweight stored. Some units achieved utilization up to 125 percent of total capacity by storing early rice for a short time, then moving it out to the mill or buyer, and using the capacity thus cleared for storing late rice. As storage costs are based on the months stored, this meant a relatively low charge per unit stored. Also, the smaller units which were primarily driers with some storage capacity stored, for the most part, seed rice which was kept until the spring planting season. But the larger units, without small bulk bins suitable for storing the individual seed supplies of different producers, used their facilities for storage of the commercial crop. Most of this moved to the mill early in the storage season, which resulted in a lower gross income per unit stored.

Storage Practices

Storage practices varied widely according to the region, type of facility, type of ownership, and combinations of services rendered to farmers. These variations in practices were responsible for some of the differences in the major problems of the managers who were interviewed concerning their respective businesses.

Storage charges:

In general, storage rates assessed were fairly uniform in Louisiana and Texas. For flat storage in sacks, the usual rate was 35 cents per 162-pound barrel for the entire storage season, or a monthly rate of 25 cents the first month, 10 cents the second month, and 5 cents the third month where the producer preferred to store on a monthly use basis. For bulk storage, the usual charge was 45 cents a barrel for the season, or a monthly rate of 25 cents the first month, 10 cents the second month, and 5 cents for the third and fourth months. In Arkansas, the usual charge for bulk storage was 10 cents per 45-pound bushel for the storage season.

Some of the larger cooperative storage units in all States, however, established a storage rate based on estimated costs of the service; they then assessed the cooperators for the difference at the end of the season if the charge was too low, or paid them a dividend if the charge was too high. The storage rates of these units were as low as 4 cents a bushel or 15 cents a barrel, which approximates 9 cents per hundredweight. The net effect of this practice was to reduce the average gross income per unit stored slightly below the prevailing rates as listed.

For rice stored in sacks in flat storage warehouses in Louisiana and Texas, the charge for sacking and sewing the sacks varied from 12 to 15 cents a sack, depending upon the size of the sack used, and averaged about 10 cents per hundredweight sacked. In effect, this sacking charge practically offset the 10 cents per barrel lower charge made in these States for rice stored in flat warehouses as compared with rice stored in bulk. In addition, the producer was required to pay for the costs of the sacks and this expense varied from 20 to 40 cents a sack, or about 25 cents per hundredweight sacked. Thus the total cost per unit for rice stored in flat warehouses was from 20 to 40 percent greater than the cost per unit when stored in bulk units.

Services supplied:

In general, services supplied in the storage operation were the same in all areas. The storage service usually included unloading, moving into and out of storage, weighing, and in the case of bulk facilities, turning at intervals to prevent deterioration. In some cases, especially in the older flat warehouse facilities, the storage operation included sponsoring auction sales at which several prospective buyers bid on each lot of rice and individual owners could accept or reject the bids. Usually a separate charge was made for insuring the stored rice, but in the Louisiana area the 45 cents per barrel rate for bulk rice included insurance on the product.

In Louisiana and Texas, the common rate charged for drying was 50 cents per barrel green weight. In southern Arkansas, the usual drying rate was 12 $\frac{1}{2}$ cents a bushel; in the northern part of the State, the common rate was 15 cents a bushel.

In Louisiana and Texas, less than a fourth of all rice stored in the units surveyed was kept in storage for as long as 6 months. About a fourth was removed from storage in less than 2 months and about half of the total remained in storage for from 2 to 6 months. In Arkansas, where a larger proportion of the total storage capacity is owned by large farmer cooperatives which also operate rice mills, about half of all rice stored was held for 6 months or longer. But even in this region a fourth of all rice stored was moved from storage units to mills within 2 months after it was stored.

Handling seed rice:

An attempt was made to determine the additional costs of handling seed rice over and above the usual costs for other rough rice placed in storage. Practically all the units surveyed reported that seed rice, when stored in bulk, was managed in the same way as all other rice once it was placed in storage and that there were no additional costs involved where the bulk bins were used to capacity. But when it was necessary to store a small lot in a large bin, this resulted in waste capacity and additional charges were made for storage. In flat warehouse units, the seed rice was usually handled in the same way as other stored rice with no additional storage costs.

The major additional expenses in maintaining seed rice appeared to be the extra drying costs, the cleaning of seed rice, and the added protective measures to prevent rodent and insect damage in the early spring months as higher temperatures became more prevalent. Most operators of rice driers charged an additional 10 cents a barrel or 3 cents a bushel for drying rice designated as seed rice. This extra charge was made because of the need for carefully cleaning out the drier to prevent mixtures and the added labor needed to prevent contamination in loading, unloading, and sacking. The usual rate charged for cleaning rough rice for seed was 40 to 55 cents a barrel in Louisiana and Texas and 7 to 12 cents a bushel in Arkansas. In practically all cases, storage operators did not assess rice stored as seed rice for any of the extra costs of insect and rodent control. They said that the storage charges for the entire season included these costs.

In comparison to bulk storage and handling, it appears that ordinary seed rice must bear costs of approximately \$1.00 per barrel above the costs of other rice stored for the season. These include 50 cents a barrel for cleaning, 10 cents added for drying, 10 cents for sacking, and about 30 cents for sacks. This amounts to about \$0.60 per hundredweight stored. Certified rice seed or seed of similar quality will cost somewhat more because of the need for even more careful handling and cleaning, drying in separate driers, and the like.

Insect and rodent control:

The major insect problem in stored rough rice was reported to be the attacks of grain weevils, especially in spring and early summer toward the end of the storage season. However, none of the 63 rice storage operators interviewed reported any significant losses from insects during the 1951-52 rice storage season. They said this was due to the fact that practically all the rice in storage was moved out of storage before the warmer spring months when damage is usually high, and also to the protective measures taken to retard insect attacks. In the bulk storage units, the stored rice was usually treated with an insecticide, which was added in the conveyor belt. In some cases gaseous insecticides were forced through the stored rice by aeration systems, whenever there was any indication of insect attacks. Damage from insects was reported to be easier to control in properly constructed bulk-storage units than in flat storage where the rice cannot be turned and thoroughly treated at intervals. When there were evidences of insect attacks in the flat-storage units, the most common practice was to spray or dust all exposed sack surfaces with DDT or some other insecticide.

Although losses from insect damage were reported almost negligible in the 1951-52 storage season, operators said that large losses were common in some years, especially during a slow rice-marketing season when a large carryover of rough rice was necessary. They thought that well-constructed bulk storage units and constant checking and treatment with insecticides were the best control measures.

Rodent-control measures commonly used included sanitation, application of poisons such as Warfarin, and the use of traps in some cases. None of the bulk storage units reported any significant damage due to rats and only 2 of the flat storage units reported losses of any economic importance.

Total cash costs for materials used in insect and rodent control averaged \$107 per firm studied (table 9). These expenses were about twice as high per operating unit for businesses with flat warehouses as they were for bulk facilities, and less control was obtained, indicating the importance of this problem for flat warehouse storage. Apparently there is no doubt that, with a relatively warm winter and an early spring, or when most of the rice must be stored for a longer period of time, losses would be greater and control expenses higher than those of the 1951-52 season.

Losses from physical deterioration in storage:

The final quality of milled rice depends to a large extent upon the proportion of striped grains due to red rice, the amount of impurities such as weed seed, the content of chalky grains, the proportion of broken grains, and the color of the milled product. Red rice, weed seed impurities, and chalky grain characteristics originate in the field; they cannot be changed by storage practices. Factors that cause discolored grains and a relatively high percentage of broken grains also may originate in the field practices or in prevailing climatic conditions when the crop is harvested. In addition, improper drying sometimes causes the milled product to have a high breakage and discolored grains. No information is available to indicate that storage methods will improve these conditions if they develop before the rough rice is placed in storage.

However, in some cases additional changes in quality occur after the rice is stored. The more common of these changes that cause economic losses is "stackburn," a discoloration of the grains resulting in a slightly yellowish milled product rather than the more preferable pearly white, and an increased tendency to break when milled. The exact causes of this deterioration in storage are not clearly known but they probably include storage at excessive moisture content, high temperatures in storage, action of bacteria and fungi, lack of aeration, and similar factors.

In an attempt to evaluate the extent of this deterioration and the resulting economic losses, each cooperating rice storage operator was asked to estimate the losses in terms of volume and of decrease in grade which occurred in his storage unit during the 1951-52 season. Only 2 of the 63 operators interviewed reported apparent economic losses from physical deterioration in storage in 1951-52. One of these estimated a loss of 70 cents per hundredweight when a volume of approximately 1,000 hundredweight became stackburned in storage, and the other reported a decline in grade from U. S. No. 2 to No. 4 of a lot of 800 hundredweight because of increased breakage and discoloration in storage.

These results do not indicate that the reported losses were the only losses in the rice stored. In most cases the rice was stored for the account of the farmer and the storage operator did not guarantee that the quality of the product would be preserved in storage, so these operators had no way of knowing the exact losses that occurred. Because most storage operators weigh the stored rice once only, usually when it is removed from storage, they were not in position to evaluate any losses in volume. Due to the difficulties of obtaining a picture of losses in storage from records of storage operators, a separate study was made to measure monthly changes in the quality and economic value of rough rice stored in different types of storage units.

Changes in Rough Rice Quality in Storage

In an attempt to evaluate changes in rough rice quality during the 1952-53 storage season, a detailed study was made of the storage operations

of 12 rough rice storage units. The sample selected for study included four units in each of the major southern rice States, Louisiana, Texas, and Arkansas. The sample included units operating solely with bulk storage facilities, those with only flat-warehouse sack-storage capacity, and those with both types of storage.

Prior to the beginning of the 1952-53 rough rice storage season, the owners and managers of each of the units selected were contacted and arrangements made to obtain basic data on each lot of rice stored. The data included the variety, moisture content, methods of drying, and volume and weight of each lot when stored. In each State, the local offices of the Federal Rice Grading Service were contacted to obtain cooperation in evaluating the quality of the rice samples obtained from the individual lots of rice.

Each cooperator was visited at monthly intervals beginning in September 1952, and a sample of each lot of rice stored was pulled, sealed in an air-tight gallon can, and taken to the local grading office for evaluation. At the grading office each sample was graded using the identical process applied to grading all rough rice, and the milling yield, moisture content, foreign matter and red rice content, cup weight, proportion of damaged kernels, and specific Federal grade were determined. A portion of each sample was then re-sealed and transported to Baton Rouge where germination tests were made. This process was repeated each month for each lot of rice in each of the cooperative storage units until that lot of rice was moved from storage. A final visit was made to each storage unit at the end of the season to determine from its records the quantity of rough rice in each lot when it was removed from storage.

The major objective of this work was to attempt to determine what changes occur in rough rice under regular commercial storage conditions and under different methods of storage.

Samples studied:

During the 1952-53 rough rice season, a total of 458 samples of rough rice was collected from the 12 cooperating storage units in Louisiana, Texas, and Arkansas. Each of these samples was examined for grade and quality characteristics in the various local Federal Rice Inspection offices, a specific Federal rice grade established, and each was tested for germination. By months, the number of samples collected and studied varied from 32 in September to 93 in November, and then declined to 28 in March, 1953. By States, a total of 210 was studied in Louisiana, 149 in Texas, and 99 in Arkansas (table 16).

Although the number of rough rice storage units was the same in each of the three States, the number of bins per storage unit was somewhat larger for the units in Louisiana and Texas than in Arkansas, resulting in a larger number of samples for these States. Also, about half of the lots studied in Louisiana and Texas were sack-storage lots in flat-warehouses, while all of the samples studied in Arkansas were from bulk storage bins. This variation

follows the usual practices in these different States since practically no rice is stored in flat-warehouses in sacks in Arkansas while this practice is common in the other two States.

Table 16.- Rice samples studied in different States, Southern Rice Region, 1952-53 storage season

Month	Samples studied in				Total 3 States
	Louisiana	Texas	Arkansas		
	Number	Number	Number		
September - - - - -	22	10	---	32	
October - - - - -	38	32	18	88	
November - - - - -	41	29	23	93	
December - - - - -	36	21	22	79	
January - - - - -	31	25	19	75	
February - - - - -	27	22	14	63	
March - - - - -	15	10	3	28	
Total - - - -	210	149	99	458	

The 1952-53 rough rice season was characterized by a very rapid movement of rice from storage units to mills and then into regular marketing channels. By the end of March there was practically no rough rice remaining in storage in the bins and warehouses of any of the cooperating units. Therefore the collection and analysis of samples was discontinued in April when, of the original samples in all bins and warehouses on which work was started, less than 10 lots of rice remained in storage.

This rapid movement in rough rice was a desirable factor from the standpoint of the rough rice producer, since it indicated a strong market for rice and the elimination of the possibility of a carryover to affect the 1953-54 crop. However, it was unfortunate from the standpoint of studying the changes in the quality and grade of rough rice in storage. Many of the lots of rice selected for study were removed from storage after only one or two months, and practically all of them were removed after less than six months of storage. In addition, all were removed before the warm weather months of spring and summer; thus the effect of the higher temperature months on grade and quality was not determined. Since the cooperating managers reported that most deterioration in grade caused by insects occurred during the latter months of the usual storage season, from April to July, the possible effects of such attacks on grade and quality deterioration under different methods of storage were not determined.

Changes in physical characteristics during the storage season:

For all long-grain varieties studied, the most important change in the physical characteristics of the rough rice was a gradual increase in moisture content during the storage season. The moisture content for long-grain samples averaged 10.8 percent in October 1952, and increased gradually to about 13 percent by March 1953 (table 17).

There were also some minor changes in the proportionate yield of head rice and in total milled rice during the season. The average head-rice yield for long-grain types was 46 percent in September, then increased to 49 percent in October, declined to 44 percent in November, and finally varied from 41 to 45 percent for the remainder of the season. Total yield of milled rice was 67 percent in September, then increased to 69 percent in October, and remained between 68 and 69 percent for the remainder of the storage period.

Table 17.- Physical characteristics of samples of rough rice studied, Southern Rice Region, December 1952-53 storage season

Month	Long-grain varieties				Medium-grain varieties			
	Samples	Head-	Total	Moisture	Samples	Head-	Total	Moisture
	studied	rice	rice	content	studied	rice	rice	content
	: yield	: yield	: content		: yield	: yield	: content	
	: Number	: Percent	: Percent	: Percent	: Number	: Percent	: Percent	: Percent
September	: 12	: 46	: 67	: ---	: 20	: 48	: 67	: ---
October	: 40	: 49	: 69	: 10.8	: 48	: 47	: 68	: 10.7
November	: 46	: 44	: 68	: 11.6	: 47	: 48	: 68	: 11.4
December	: 38	: 41	: 68	: 11.8	: 41	: 47	: 68	: 12.0
January	: 39	: 45	: 68	: 12.2	: 36	: 46	: 68	: 12.2
February	: 30	: 44	: 69	: 13.9	: 33	: 47	: 68	: 12.4
March - -	: 15	: 41	: 68	: 12.3	: 13	: 47	: 67	: 12.6
	: :	: :	: :	: :	: :	: :	: :	: :

Similar changes in major physical characteristics were indicated for the medium-grain varieties. For all medium-grain samples studied, moisture content increased from 10.7 percent in October to 12.6 in March. However, the head-rice yield and the total yield of milled rice varied less widely for the medium-grain types than for the samples of long-grain varieties.

Although there were minor changes in physical characteristics from month to month for the different grain-type groups, these changes were not sufficient to affect the final grade classification. Thus all samples which were classified as U. S. No. 2 at the beginning of the storage season in September were classified in the same grade at the end of the study period in March. In only two of the samples studied was there an indication of

grain discoloration due to storage or high moisture content as the storage season progressed, and for these samples the change was not sufficient to cause an adjustment in grade. Since there was no indicated insect damage, there were no adjustments in grade for this reason. However, it should be kept in mind that this study extended only through March and did not cover the warm weather months when stackburn and insect damage losses are reported to be more serious.

Variations by varieties and types of storage:

The variations in major physical characteristics associated with rice quality in identical lots of the Zenith variety from month to month during the storage season are presented in table 18. The facts indicate an early increase in total and head rice yield during the first month after storage, followed by a gradual decline in these quality factors. Changes in moisture content followed the same general trend as for all varieties, a small but gradual increase during the season.

Table 18.- Changes in physical characteristics of identical lots of Zenith rough rice in storage, 1952-53 storage season

Months	:	Samples studied	Changes from month to month		
			Head-rice	Total	Moisture
			yield	rice yield	content
		Number	Percent	Percent	Percent
September to October - -	:	15	3.9	1.5	-0.3
October to November - -	:	32	-0.9	-0.4	0.4
November to December - -	:	31	-2.2	-0.4	0.6
December to January - -	:	26	-0.3	0.1	0.4
January to February - -	:	23	0.1	0.8	0.0
February to March - - -	:	12	2.2	0.2	-0.1
	:				

During the period covered there was little difference in changes in quality factors according to the method of storage. For most quality factors the lots stored in bulk bins varied about the same amount as the season progressed as the lots stored in sacks in flat warehouses (table 19). In terms of the total yield of milled rice, the Zenith lots stored in bulk had a slight increase for the season while those stored in sacks declined slightly. However, in view of the small number of samples and the possibility of variations in the sampling process, this difference does not appear to be significant. Similar minor differences were indicated in the moisture content.

Table 19.- Changes in physical characteristics of identical lots of Zenith rice under different methods of storage, 1952-53 storage season

Months	Samples studied	Changes from month to month		
		Head-rice	Total	Moisture
		yield	rice yield	content
	Number	Percent	Percent	Percent
Bulk storage:				
October to November -	10	-0.9	-0.2	0.3
November to December -	10	-0.9	0.2	0.3
December to January -	6	3.0	0.8	0.0
January to February -	6	0.2	2.8	0.0
Sack storage:				
September to October -	15	3.9	1.5	-0.3
October to November -	22	-0.9	-0.6	0.4
November to December -	21	-2.9	-0.8	0.7
December to January -	20	-1.3	-0.1	0.6
January to February -	17	-0.1	0.1	0.0
February to March - -	12	2.2	0.2	-0.1

The variations in physical characteristics during the season for the most important long-grain variety in the region, Bluebonnet, are shown in table 20; the changes for this variety under different storage methods are

Table 20.- Changes in physical characteristics of identical lots of Bluebonnet rough rice in storage, 1952-53 storage season

Months	Samples studied	Changes from month to month		
		Head-rice	Total	Moisture
		yield	rice yield	content
	Number	Percent	Percent	Percent
September to October - -	4	2.7	1.0	0.1
October to November - -	18	-5.0	-1.5	0.9
November to December - -	24	-2.2	0.0	0.3
December to January - -	21	2.0	-0.2	0.4
January to February - -	18	-3.3	-0.1	1.6
February to March - - -	7	0.0	0.0	-0.6

indicated in table 21. During the season, this variety reacted in about the same manner as the medium-grain type, Zenith, and in the same direction. There was an increase in the head-rice and total-rice yield the first month, followed by a gradual decline in succeeding months, and a gradual increase in moisture content throughout the storage period. There were some differences in total and head rice yield and in moisture content between Bluebonnet rice stored in bulk and in sacks but these variations were not significantly large to indicate any general tendency.

Table 21.- Changes in physical characteristics of identical lots of Bluebonnet rice under different methods of storage, 1952-53 storage season

Months	Samples studied	Changes from month to month		
		Head-rice	Total	Moisture
		yield	rice yield	content
	Number	Percent	Percent	Percent
Bulk storage:				
October to November -	8	-5.5	-1.7	0.9
November to December -	13	2.1	-0.5	0.4
December to January -	12	1.9	-0.8	0.4
January to February -	8	-1.9	0.1	2.3
February to March -	3	-1.0	0.0	0.2
Sack storage:				
October to November -	10	-3.7	-1.3	0.9
November to December -	11	-3.3	0.6	0.3
December to January -	9	2.1	0.6	0.3
January to February -	10	-4.3	-0.3	0.9
February to March -	4	1.0	0.0	-1.3

Changes in germination:

When stored under reasonably good conditions rough rice appears to increase in germination during the storage period. For 24 identical lots, stored in bulk facilities, the germination averaged 88 percent when the rice was placed in storage and 92.1 when the rice was removed from the storage facility. For 35 lots stored in sacks in flat warehouses, the germination rate increased from 85.1 percent to 88.6 percent during the season (table 22).

There was no indication of significant differences in changes in germination according to the method of storage or the type of rice stored. However, as the lots studied were removed from storage during February and March, the variations in germination and the possible differences according to type of storage in the later months of the usual storage season are not shown in this study.

Table 22.- Changes in germination of identical lots of rough rice when stored for 2 months or longer, Southern Rice Area, 1952-53 storage season

	Samples studied	Average germination	
		When placed in storage	When removed from storage
	Number	Percent	Percent
Bulk storage:			
All varieties - - - - -	24	88.0	92.1
Long grain types - - -	14	87.4	91.3
Medium grain types - -	10	88.9	93.2
Sack storage:			
All varieties - - - - -	35	85.1	88.6
Long grain types - - -	19	83.5	87.7
Medium grain types - -	16	87.1	89.7

Changes in volume:

For the 16 identical lots stored in bulk facilities on which weights were obtained at the beginning and at the end of the storage season, the average loss in weight during the season was 4.6 percent. For the 13 identical lots which were stored in sacks in flat warehouses, the weight loss averaged 1 percent for the season (table 23). This indicates an

Table 23.- Changes in average weight per lot stored for rough rice when stored for 2 months or longer, Southern Rice Area, 1952-53 storage season

	Samples studied	Average weight per lot stored		Percentage loss in weight
		When placed in storage	When removed from storage	
	Number	Pounds	Pounds	Percent
Bulk storage:				
All varieties - - - - -	16	175,470	167,434	4.6
Long grain types - - -	6	378,374	357,628	5.5
Medium grain types - -	10	55,228	53,319	3.5
Sack storage:				
All varieties - - - - -	13	77,350	76,598	1.0
Long grain types - - -	10	85,980	85,108	1.0
Medium grain types - -	3	48,534	48,229	0.7

important difference in relative losses according to method of storage. However, the number of samples studied and the methods of establishing weights were such that no basic conclusion should be made in this matter until more complete studies are made. Practically none of the storage units studied followed the practice of obtaining accurate weights of dried rice when it was placed in storage. Since drying charges were generally based on the weight of the rice as it came to the drier, the weight of the rough rice on a wet basis was obtained and the amount stored was estimated according to a formula and depending on the proportion of moisture removed in drying. For lots stored in sacks, the usual practice was to weigh several sacks of a given lot which might include from 100 to 1,000 sacks, and estimate the beginning and ending weight on this basis.

Costs and Returns for On-Farm Storage Units

In the initial phase of the field work for the commercial rice storage study, leading producers and rice storage operators in the Southern Rice Area were requested to estimate the relative volume of rough rice stored on farms in each area. These estimates resulted in an average of about 5 percent for the Arkansas rice area and less than this amount for the other regions. Although this figure appeared to be relatively low, it was proved to be approximately correct when county agents in all leading rice counties in the Southern Rice Area were contacted for information relative to on-farm storage of rough rice. Based on a survey made by county agents, a sample of on-farm storage units was selected for study, including 17 in Arkansas, 6 in Texas, and 2 in Louisiana. Most of the on-farm storage units in the sample were in Arkansas because the practice of storing rough rice on the farm was much more common in that State than in other parts of the region.

A major reason for greater emphasis on on-farm storage in Arkansas appeared to be the prevailing type of farming which permitted greater utilization of on-farm storage capacity than was possible in other States. Many rice farms in Arkansas also produced soybeans, which were harvested and stored in the fall months, and lespedeza seed which could be stored in the same units. In addition, many farms produced oats, a spring-harvested crop, which could be stored in on-farm storage units until the fall crop of rice, soybeans, or lespedeza seed was available for storage. In the Louisiana and Texas rice areas, climatic conditions and other factors prohibited production of these crops on rice farms and the only use that could be made of on-farm facilities was rice storage. This made on-farm storage facilities relatively expensive because of the more limited possibilities for full utilization throughout the year.

Rice production and disposition:

The 25 farmers who operated on-farm storage units were on farms that were about twice as large as the average rice farm of the region. These farms averaged more than 1,500 acres with 432 acres of rice per farm in 1951 (table 24).

Table 24.- Rice production on 25 farms with on-farm storage facilities,
Southern Rice Area, 1951 season

Production items	Farms reporting	Average per farm reporting	Average, all farms
	Number	Acres	Acres
Acres in farm - - - - -	25	1,524	1,524
Acres in rice:			
Bluebonnet - - - - -	20	183	147
Zenith - - - - -	16	185	118
Rexora and Texas Patna - - -	6	352	84
Rexark - - - - -	11	87	38
Nira - - - - -	4	199	32
All other varieties - - - - -	6	56	13
Total - - - - -		432	432
		Cwt.	Cwt.
Rough rice produced:			
Bluebonnet - - - - -	20	4,524	3,619
Zenith - - - - -	16	4,156	2,660
Rexora and Texas Patna - - -	6	8,933	2,144
Rexark - - - - -	11	2,005	882
Nira - - - - -	4	4,839	774
All other varieties - - - - -	6	1,347	323
Total - - - - -		10,402	10,402
		Cwt.	Cwt.
Rough rice stored:			
Bluebonnet - - - - -	20	3,107	2,485
Zenith - - - - -	16	3,005	1,923
Rexora and Texas Patna - - -	6	7,583	1,820
Rexark - - - - -	11	1,855	816
Nira - - - - -	4	4,816	771
All other varieties - - - - -	6	1,200	288
Total - - - - -		8,103	8,103

The varieties of rice produced were the same as those grown by most farms in the region. About 34 percent of the total area of rice on these

farms was of the Bluebonnet variety, a medium-season long-grain type; 27 percent was planted to Zenith, a short-season medium-grain type; 19 percent was in Rexora and Texas Patna, long-season long-grain types; and the remaining 20 percent was planted to Rexark, Nira, Century Patna, and Magnolia. Staggering the varieties of different seasonal requirements and grain types is common practice in the Southern Rice Area. This is done so that the harvesting and drying equipment may be utilized over a longer period of time to avoid overcrowding in any one week and to produce rice of different qualities to meet varied market demands.

These farms produced an average of 10,402 hundredweight of rough rice per unit in 1951, of which 22 percent was sold at harvesttime, 62 percent was stored in on-farm storage units for use as rice seed in the next season, or for sale at a later date, and 16 percent was stored in nearby commercial rough rice storage units (table 25).

Table 25.- Disposition of rough rice produced, 25 farms with on-farm storage units, Southern Rice Area, 1951-52 storage season

Variety	:	:	Proportion disposed by		
			Sales	Stored	Stored in
			at the time	at	commercial
			of harvest	the farm	units
		Cwt.	Percent	Percent	Percent
Bluebonnet - - - - -	:	3,619	31.3	55.2	13.5
Zenith - - - - -	:	2,660	27.7	45.6	26.7
Rexora and Texas Patna -	:	2,114	15.1	84.9	---
Rexark - - - - -	:	882	7.5	64.0	28.5
Nira - - - - -	:	774	---	100.0	---
All other varieties - -	:	323	10.9	89.1	---
Total or average - - -	:	10,372	18.5	73.1	22.9

The general practice on these farms was to sell a small part of the crop at harvesttime in order to obtain operating capital; to store a large part of the higher quality crop in on-farm storage units for use as seed or for sale in late winter or early spring, depending on market conditions; and to store the rest of the crop, which was usually of lower quality, in commercial units for sale to rice mills later in the marketing season. They said they preferred to store their higher quality seed rice on the farm while placing the commercial crop on the market immediately after harvest or in commercial warehouses. With this practice they saved transportation costs to and from commercial storage units in the case of seed rice. They were also able to control their seed rice better, thereby reducing the danger of contamination.

Variations in prices:

The average price received, by varieties, for all rice sold at harvest-time on the sample farms is presented in table 26. These prices varied from \$4.33 per hundredweight for Bluebonnet to \$5.25 for Rexora and Texas Patna. In general, the prices received reflected the market conditions at that time. Although Zenith usually sells for less than Bluebonnet, these varieties, quality considered, brought about the same price for a period of several weeks in the 1951-52 season.

Table 26.- Average prices for rice according to method of disposition, 25 rice farms with on-farm storage units, 1951-52 storage season

Variety	Price per hundredweight when disposed by				
	: Sale	: Stored in on-farm units	: Stored in commercial units		
	: at the	: Estimated	: Price or	: Estimated	: Price or
	: time of:	: price at	: value at end:	: price at	: value at end
	: harvest:	: harvesttime	: of season	: harvesttime	: of season
	: Dollars:	: Dollars	: Dollars	: Dollars	: Dollars
Bluebonnet - -	: 4.33	: 4.42	: 5.19	: 4.61	: 5.10
Zenith - - - -	: 4.42	: 4.41	: 5.25	: 4.60	: 4.78
Rexora and	:	:	:	:	:
Texas Patna -	: 5.25	: 5.07	: 5.65	: ---	: ---
Rexark - - - -	: 4.62	: 4.98	: 5.28	: 3.67	: 4.96
Nira - - - - -	: ---	: 4.55	: 5.00	: 4.50	: 4.88
All other	:	:	:	:	:
varieties - -	: 4.50	: 4.51	: 5.03	: ---	: ---
Average -	: 4.80	: 4.63	: 5.28	: 4.43	: 4.95

For all rice stored in on-farm and commercial units, the cooperating producers were requested to list the price at which this rice could have been sold at harvesttime, before storing, and the price actually received when it was sold from storage, or, in the case of rice kept for seed, the prevailing price at the end of the storage season. For rice stored in on-farm units, the average sale price at harvesttime was \$4.63 per hundredweight. For this same rice, the price received, or the prevailing price at the end of the season, was \$5.28 per hundredweight, or an increase of \$0.65 per hundredweight. This amounted to an increase of 11 percent in average value. For rice stored in commercial units, the value at harvesttime was \$4.43 per hundredweight as compared to the sale price of \$4.95 received when sold from storage, or an increase of \$0.52 per hundredweight. This was also an 11-percent increase. Although the percentage increase in value varied for the different varieties, all varieties increased in price during the storage period.

These data indicate that the producers surveyed made a gross saving of about \$0.50 to \$0.65 per hundredweight for all rice stored in the 1951-52 season. Considering their storage costs, this resulted in a net gain of about 5 percent over the prices they would have received if the rice stored had been sold at harvesttime. If 1951-52 rice market conditions are representative of long-time conditions in the Southern Rice Area, the producer who can afford to wait for his income will make substantial savings by storing his rice either in commercial or in on-farm units, assuming that he can store as cheaply on the farm as in the larger commercial businesses.

But it should be kept in mind that storing rice, like holding any other farm commodity, is a gamble. In some years, the price increases rapidly and large gains are made. In other years, the increase in price barely pays the storage costs. And at other times, the decline in price may be such that large losses are incurred. A long-time study of rough rice prices during the 20 years from 1920 to 1939 indicates that on the average, the price of rough rice increased 6 percent from the harvest season to the end of the marketing year. 7/

Costs for on-farm storage units:

Most drying of rice is done in either commercial column-type continuous flow or batch-type driers from which the rough rice is removed after drying and placed in bulk storage units or sacked for removal to flat warehouses. However, the popularity of bin drying has increased in recent years. This method consists of forcing heated or unheated air through a bin of wet rice. The rice is not moved until the desired moisture content is reached. In some cases the rice is stored in the same bin in which it is dried, without moving. This method of drying and storage lends itself readily to on-the-farm drying and storage. 8/

For the 25 farms studied, 11 had conventional driers of the continuous flow or batch-type used by commercial units with accompanying bulk storage capacity; 5 operated bin drier systems in which hot air was forced through the bulk bins and the rice left in these bins after drying; and 9 had on-farm bulk storage facilities for rough rice without drying facilities of any type. Two of the 11 units with conventional driers and bulk storage also had additional flat-warehouse storage for keeping sacked seed rice. Practically all the facilities for all units were built of corrugated metal.

The average costs for operating each of these different types of rough rice storage units for the 1951-52 season are shown in table 27. As in the case of the commercial drying and storage units, a detailed accounting breakdown of costs according to drying, storage, and other operations was not available. However, an estimate was obtained as to the proportion of

7/ EFFERSON, J. N. The Production and Marketing of Rice, pp. 526-528. New Orleans, La. 1952.

8/ TEXAS AGRICULTURAL EXPERIMENT STATION ... op. cit., pp. 9-15.

Table 27.- Costs of operating on-farm rice storage units, 25 farms, Southern Rice Area, 1951-52 storage season

Items of cost	Costs per operating unit		
	11 units with	5 units with	9 units
	conventional driers	bin driers	without driers
	Dollars	Dollars	Dollars
Direct costs:			
Labor - - - - -	1,478	729	131
Electricity and fuel - - - - -	1,605	165	62
Insect and rodent control - - - - -	57	121	8
Miscellaneous - - - - -	368	351	27
Total - - - - -	3,508	1,366	228
Overhead costs:			
Depreciation - - - - -	2,571	1,910	344
Insurance - - - - -	447	397	103
Repairs - - - - -	650	120	244
Interest paid - - - - -	45	200	35
Taxes - - - - -	146	35	5
Total - - - - -	3,859	2,662	731
Total, all costs - - - - -	7,367	4,028	959
Percentage of costs for storage:	14.5	43.4	100.0
Total storage costs-----dollars:	1,066	1,748	959
Volume stored:			
Rice-----cwt.:	9,622	11,430	2,947
Other crops-----cwt.:	818	3,600	2,122
Total-----cwt.:	10,440	15,030	5,069
Cost per cwt. stored-----cents:	10.2	11.4	18.9
Storage capacity-----cwt.:	16,805	12,762	9,874
Percentage of full use - - - - -	62.1	117.7	51.3
Percentage of full use for rice:	57.3	89.6	29.8

total costs that should be charged to storage. Using this estimated percentage, and applying it to the total costs of operation, an approximation of the actual storage costs was determined. This varied from 10 cents per hundredweight for units with conventional driers to 11 cents for those with bin driers, and 19 cents for units without drying facilities.

These average costs per unit stored included the total volume stored of all commodities throughout the year. For the larger on-farm storage units with conventional driers, rough rice accounted for more than 90 percent of the storage use. For the bin drier storage units, rough rice occupied 75 percent of the total storage capacity used. For the smaller units without driers, utilization for rough rice storage amounted to less than 60 percent of total use. The other commodities stored included soybeans, oats, and lespedeza seed.

A major factor affecting costs per unit for storage was the relative utilization of full capacity. Units operating conventional driers used only 62 percent of total available capacity compared with 118 percent for the bin drier units and 51 percent for units without driers. The bin drier units averaged a utilization in excess of total capacity by means of multiple use. These operators used about 90 percent of total capacity in the fall of 1951 for the storage of rough rice. Then they moved a sufficient quantity of this rice out of storage before the oat harvesting season in the spring of 1952 to store oats up to an additional 27 percent of available storage space.

When questioned as to the relatively low use of existing storage capacity, most of the cooperators said they maintained on-farm storage facilities for two major reasons: (1) To have a safe, reliable place to store seed rice and reduce costs by saving transportation costs from and back to the farm, and (2) to have available emergency storage capacity sufficient to care for most of the commercial crop in any season when marketing conditions were such that a severe price penalty would be incurred if the crop could not be stored. They reported that commercial storage units could be used for the commercial crop in slow-movement crop years, but that existing commercial storage capacity, although available in good years because the crop moves rapidly, would be difficult to obtain if the bulk of the rice produced in the region had to be stored. In the 1951-52 season, marketing conditions and movements of rough rice to mills were reasonably good and it was not necessary to utilize all existing on-farm storage. But they felt that they were justified in maintaining such facilities, even if they were not used half the time, as insurance against bad years such as the 1947-48 and 1948-49 seasons. In those years, the price of rough rice dropped drastically early in the harvesting season because of slow demand and lack of storage facilities, but it increased materially after the end of the harvest season.

Problems and opportunities;

The main single item of cost for all different types of on-farm rice storage units was depreciation. This expense accounted for more than a

third of all costs for each type of operating unit. Units with conventional driers estimated that their investments in buildings and equipment would last approximately 18 years and the original capital investment of \$42,672 per unit would depreciate at the rate of \$2,571 per year (table 28). Units with bin driers also averaged 18 years as the estimate of useful life and had a depreciation cost of \$1,910 per unit on an original investment of \$25,958. Units without driers were estimated to have a useful life of about 24 years and had a depreciation cost of \$344 annually on a capital investment cost of \$9,152.

Table 28.- Capital values for 25 on-farm rice storage units, 25 farms, Southern Rice Area, 1951-52 storage season

	Per unit values		
	11 units with conventional driers	5 units with bin driers	9 units without driers
	Dollars	Dollars	Dollars
Original cost - - - - -	42,672	25,958	9,152
Depreciated value, 1952 - -	30,333	22,902	5,060
Market value, 1952 - - - -	41,636	23,900	8,622
Replacement cost, 1952 - - -	55,545	29,398	15,289
Age of facilities, 1952			
years:	4.8	1.6	11.9
Remaining years of use-years:	13.7	16.4	12.5
Depreciation costs, 1952			
dollars:	2,571	1,910	344

The costs of establishing these on-farm rice storage units points out one of the major problems of rice farmers in regard to on-farm storage. Even for relatively small units without drying capacity, investment costs of about \$10,000 were needed and the current replacement costs of these facilities was in excess of \$15,000. For units with driers, total investment and replacement costs were from two to four times as great. Such costs, which can only be recovered over a long period of time, are difficult to carry on the average rice farm with a relatively low volume of business. These costs could be reduced if storage units without driers were established, but costs per unit of storage were higher with these types of facilities. Other practical considerations, such as transportation costs to the drier, back to the farm, then back to the buyer, make such facilities relatively expensive

unless multiple uses can be found for them, as was the case on some Arkansas rice farms. In Texas and Louisiana, no large-scale multiple uses were possible, which probably accounts for the relative scarcity of on-farm storage in these States.

The interest charge included in table 27 was the actual interest paid on financing to establish storage facilities. If the prevailing interest rate of approximately 5 percent for reasonably secure long-time investments were applied to the capital invested in storage facilities, the total costs and costs per unit stored would be increased by about 20 percent. If interest on the market value or replacement value were considered at the same rate, costs per unit stored would be about 30 percent greater than the actual costs indicated in table 27. Even considering these expenses, however, the average expense per hundredweight of rice stored for the 1951-52 season varied from 15 to 25 cents, while producers received from 50 to 65 cents per hundredweight in increased prices for having stored the rice. Thus the on-farm storage operation was profitable in the 1951-52 season even with somewhat less than full use of available storage capacity. But these producers could have utilized local commercial storage capacity in many cases at about the same cost as storage on their own farms. They made no significant financial gain by maintaining on-farm storage facilities in 1951-52. They did have the assurance that they had safe storage for their seed rice without danger of contamination and that they had available emergency storage facilities if such facilities were needed in a slow marketing season.

Of the 25 producers surveyed, 9 said that the major reason they had established on-farm storage facilities was the desire to be able to hold their rice every year and sell on the best market rather than be forced to sell immediately after harvesting. While adequate commercial storage was available in years when markets were good and it was not needed, they felt that such facilities could not be depended upon in slow marketing years when everyone wanted to store rice. Five of these cooperators said they established their facilities because they believed rice could be stored on the farm at a lower cost than in commercial facilities. Seven said their major justification was the need to have drying facilities available so that the crop could be harvested at the optimum time, avoiding the necessity for speeding up or delaying harvest in order to meet the local commercial drier schedule. The remaining four producers said their facilities were established in order to have safe efficient storage for seed rice.

These cooperators said that the major disadvantages of on-farm rice storage were: (1) The extra costs of handling in the case of non-drier units and in the case of sales from on-farm units to commercial buyers in distant areas; (2) the speculative nature of holding rice in which they assumed the risk of price and quality declines; (3) the danger of losses due to insects, rodents, and physical changes which was felt to be greater in the smaller on-farm units than in the larger, more carefully supervised commercial units; and (4) the difficulty of obtaining the advantage of competitive bidding on too few lots and a relatively small volume per lot in contrast to the opportunity afforded by the larger storage units where prospective buyers had a wide range of qualities and lot sizes on which to bid.

In reference to losses in storage, only 2 of the 25 operators contacted reported any significant losses. Both of these cases were instances of "stackburn" which they said reduced the value of small lots of rice to the extent of about 10 cents per 100 pounds. They were of the opinion that these losses were due to improper drying and storage at too high a moisture content rather than to any defect in the storage facilities.

Comparative Costs of Storage with Different Types of Storage Units

Comparative storage costs for the three different types of commercial rough rice storage facilities most commonly found in the Southern Rice Area and the three different types of on-farm storage are shown in table 29. Using the approximation method of establishing storage costs for multiple-unit enterprises, as explained previously, there was relatively little difference in storage costs per unit for the various types of commercial units and for the on-farm units with driers. For these last units, the total costs, including an interest cost of 5 percent on the depreciated value of the capital investment in buildings and equipment, varied from 12 to 15 cents per hundredweight stored.

The on-farm units without driers, however, had unit costs averaging 23 cents per hundredweight on all products stored. These costs were higher than the other types of enterprises because they were established solely for the purpose of storage; they did not have the cost-reducing advantage of additional enterprises--such as drying, merchandise sales, seed cleaning and treating, and similar operations--as was true of all the other units. Also, use in relation to capacity was less in the case of on-farm units without driers than for any of the other groups.

When costs were adjusted for differences in use in relation to capacity, and estimated costs were computed which would have occurred had all units been used to the fullest, average costs varied from 10 to 13 cents per 100 pounds for the commercial units and the on-farm units with conventional driers. On this basis, similar unit costs were about 17 cents per hundredweight for on-farm drier units and units without drying facilities.

Table 29.- Comparison of costs of storage for different commercial and on-farm rice storage units, Southern Rice Area, 1951-52 storage season

Items of storage cost	Per unit costs					
	Commercial units			On-farm units		
	Bulk and flat storage	Bulk storage only with drier	Flat storage only without drier	With usual driers	With bin driers	Without driers
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Actual expenses:						
Direct costs 1/ - -	43,724	25,232	12,212	3,508	1,366	228
Overhead costs, except interest -	26,016	16,826	3,671	3,814	2,462	696
Interest costs 2/ -	8,059	8,435	1,142	1,517	1,145	253
Total expenses -	77,799	50,493	17,025	8,839	4,973	1,177
Percentage of costs for storage - - - -	18.9	16.9	33.2	14.5	43.4	100.0
Total storage costs -	14,704	8,533	5,652	1,282	2,158	1,177
Added direct costs for full use for rice 3/	2,829	795	755	384	69	537
Storage costs if full volume of rice were stored - - - - -	17,533	9,328	6,407	1,666	2,227	1,714
Rice stored-----cwt.	99,907	68,599	44,500	9,622	11,430	2,947
Other products stored cwt.	---	---	---	818	3,600	2,122
Total products stored cwt.	99,907	68,599	44,500	10,440	15,030	5,069
Total capacity---cwt.	134,102	81,356	57,510	16,805	12,762	9,874
Percentage rice stored of full capacity	74.5	84.3	77.4	57.3	89.6	29.8
Costs per hundred-weight:						
Actual costs-cents:	14.7	12.4	12.7	12.3	14.4	23.2
Estimated costs with full use of capacity for rice storage cents:	13.1	11.5	11.2	9.9	17.4	17.4

1/ Includes all direct expenses except the costs of merchandise purchased for re-sale. 2/ Interest computed at 5 percent of the depreciated capital investment. 3/ Computed by (1) determining proportion direct costs were of all costs, (2) applying this percentage to the storage costs to obtain direct storage costs, (3) increasing the direct storage costs in proportion to the amount the unit operated below full capacity, and (4) subtracting this full capacity direct cost total from the actual direct cost total to determine the increase. This computation assumes that overhead costs would remain the same regardless of the volume stored.

CONCLUSIONS

The Southern Rice Area appears to be reasonably well supplied with storage facilities for rough rice sufficient to handle a volume equal to that produced in 1951 and 1952. However, almost half of this storage capacity is in the form of the old-type flat warehouses in which rough rice can be stored only after it is bagged. Also, the available storage capacity is not uniformly distributed throughout the production area and some regions, especially the western part of the Texas rice area, have a storage capacity deficit.

Most of the storage capacity for rough rice in the Southern Rice Area outside of mill ownership is in the form of large commercial units operated as independent businesses or farmer cooperatives. These units are usually multiple-purpose businesses which operate as rice driers, handle farm supplies, and provide other services for farmers. This multiple-purpose storage-drying-farm service organization reflects the practices commonly followed in handling rough rice by the now universal combine-drier method of harvesting. These businesses are generally more profitable than those specializing only in the storage of rough rice.

Although the operation of multiple-purpose businesses, including storage of rough rice, was indicated to be reasonably profitable in the 1951-52 season, the facts also indicate that in the event expanded storage facilities are needed beyond 1951-52 levels, such facilities may be established slowly. The units studied for the 1951-52 season were built at lower prices and while they made a good return on their capital investment, the return on a market-value or replacement-cost basis would have been so low as to discourage extensive investments in new facilities. In addition, opportunities for establishing high-volume operations for any new units established would be more limited than for those now in the business, where existing storage capacity already approximates total needs. Also, the possibilities for acreage allotments and/or marketing quotas with a resulting overall reduction in volume is such as to retard long-time investments in new units.

The function of storage of rough rice is twofold: (1) To allow the producer to sell more advantageously and (2) to move rice into consumption at an even rate throughout the year. Rice is less perishable before milling so that most of the storage is in rough form. In performing the first major function, that is, to allow the producer to sell more advantageously, the ownership of storage facilities becomes an important factor. Storage capacity in the ownership of buyers, exporters and mills may not be freely available to producers. For this reason, even though the total storage capacity is adequate, additional facilities for the use of producers would probably be desirable.

From the viewpoint of the storage operator, there was little difference in the costs of storing rice in bags in flat warehouses as compared with

storage in bulk facilities. As compared with bulk facilities, costs of storing rough rice in flat warehouses resulted in lower overhead costs but higher labor costs, and these two major cost items largely offset each other. From the viewpoint of producers, however, use of bulk facilities was more efficient. Producers who stored rice in flat warehouse units had to buy the sacks used, and pay for the labor used in sacking and sewing the sacks and for extra labor in handling the sacked rice. Total costs to the producer for storing rough rice in flat warehouses, including the storage charge and the additional expenses for sacking rice, was from 20 to 40 percent greater than costs of storing in bulk storage facilities. The savings made possible, when storing in bulk, by the elimination of the costs of sacks and reduced labor expenses in handling, have caused an increased demand for bulk storage facilities throughout the region.

On-farm facilities for the storage of rough rice were restricted primarily to producers who had sufficient rice to justify an investment of from \$25,000 to \$50,000 for such facilities. These producers, when they used their units efficiently, stored rice as cheaply as it was stored by the larger commercial businesses. The farm storage units without some type of drier had relatively high costs of storage and additional costs of transportation. Thus, on-farm storage of rough rice appears to be possible only for the larger farms and in connection with some type of rice drier.

The problem of whether to store rice in commercial units, or in on-farm storage, or to sell the crop at harvesttime is one that must be solved by each producer according to his individual judgment and his specific financial situation. From 1920 to 1939, prices of rough rice, on the average, increased 6 percent from harvest to the end of the storage year. In the 1951-52 season, prices for rice of identical quality increased about 10 percent. In the 1951-52 season, commercial storage rates for rough rice amounted to about 5 percent of the price at the beginning of the storage season. Thus, producers who stored their rice in commercial units paid 5 percent of the value of their crop for storage and received a price at the end of the harvest season that was 10 percent higher than the price they would have received had they sold at harvesttime. If the long-time average difference of only 6 percent between harvesttime and end-of-storage-season prices had existed in 1951-52, however, the net earning to the producer would have been only 1 percent, or about 5 cents per hundredweight stored.

Storing rice, as holding any other farm commodity, is a gamble. In some years, large gains are made. In other years, large losses are incurred. Over a long period of time, a slight gain might accrue from consistent storage and selling late in the season, but this gamble should be taken only by those who have financial resources to sustain the risk of a large loss in any one year. More efficient, cheaper storage facilities will help to increase the margin. At the same time, a larger proportion of the crop is likely to move into storage, resulting in a change in the relationship between the beginning and end of the season prices.

This study has indicated some of the more important problems involved in the storage of rough rice in the Southern Rice Area. Although the

overall storage capacity is apparently adequate, many of these facilities are in the form of flat warehouses which are more expensive to use than the more recently built bulk facilities. The flat warehouses are not likely to be abandoned as they represent large investments. Their existence may retard the establishment of additional new bulk facilities. Thus, it appears that the most desirable solution to the problem is to adapt flat warehouse facilities for bulk storage by modifying these structures to include proper bins and mechanical equipment for moving the rice into and out of storage. It appears that research is needed to determine the most efficient methods, types of materials, and changes in management practices that are desirable in order to convert flat warehouses to bulk facilities.

The study has indicated the importance of full utilization of available storage capacity to efficiency in storage. In bulk storage facilities, full utilization has been difficult to obtain because the volume of rice delivered at any given time by a specific producer is not likely to be the same as the capacity of a given bin. The result is many partially filled bulk bins. Some of the large cooperatives which also operate rice mills have partly solved this problem by the practice of commingling rough rice after it is dried, attempting to place all rice of a given variety and quality in a given bin until it is completely filled. However, because rice varies not only by variety and the six major official grades, but also by the yield of head or whole rice, for the most part individual producers are not interested in commingling. Complete separation by variety and grade as well as by head rice count would require more bins than are available at most installations. Thus, such a procedure could not entirely solve the problem.

Efficient utilization of capacity may be approached in two ways: (1) Further research on grades and standards of rough rice to make commingling a more practicable possibility for the producer who wants to maintain ownership of his rice after it is stored, and (2) development of temporary bins of different sizes within the large permanent bins so that a given bin could be more fully utilized when many small lots of different quality or variety are delivered for storage. The additional research on grades should include appraisal of the important factors in variety, grade or head rice count that influence prices paid by the mills. This would help in determining lots that could be combined for increased efficiency in use of storage capacity.

The results of the experimental study of changes in rough rice in storage can at best be called inconclusive. This was due to the unusual marketing season in which the rough rice stored by the cooperating individuals and firms was moved from storage after from only one to four months of storage, and before major changes took place with the advent of warmer weather. Also, the sample of storage units studied appeared to be above average in types of equipment used and in storage methods. For this first experimental study, such a biased sample was selected because of the necessity of obtaining full cooperation to visit the unit and pull a sample of rice from every storage lot every month. Those who freely offered such cooperation were the more efficient operators in the area.

The results indicate certain facts, however, which if verified by further more intensive research would be of great value to the industry. The indication that rough rice increases in head-rice and total-rice yield during the earlier months of storage and declines later on, if verified, would help to explain the differences in the grades determined by different buyers on the same lot of rice when graded at different times. The indicated gradual increase in moisture content, if verified, would assist in developing more uniform drying practices according to the planned period of storage. A more intensive study on either the experimental basis or along the approaches used in this work conducted through the storage season from September through July would possibly indicate the relative changes for different types under different storage conditions in quality factors and in storage deterioration.

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